

VEGETABLE CROPS

a disease management guide



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Foreword

This book provides descriptions and management recommendations for diseases of vegetable crops in Queensland. It is the second in a series which will replace the current *Handbook of Plant Diseases In Colour - Volume 1 (second edition)*. The handbook will not be published in the format of its predecessor because it has not proved feasible to regularly update the sections dealing with chemical registrations and disease management recommendations, which are constantly changing. Therefore the original handbook has been separated into two parts, with current recommendations being published separately from the colour sections.

The future in plant pathology lies in an integrated approach to disease control where resistant cultivars, crop rotation, biological control and other cultural practices, as well as fungicides, are all important in our bid to economically reduce disease and produce quality vegetables. These measures are emphasised in this publication, with many being specifically designed to counter the problem of resistance to fungicides and to reduce the risk of pesticide residues in produce.

Recommendations for fungicide use are correct at the time of printing but changes in registrations occur regularly. If in doubt concerning the use of a particular chemical on a crop, consult the extension horticulturists of this Department who have access to the computer data base 'Infopest'. This system is continually updated and provides information on all current registrations of agricultural chemicals available in Queensland. New information on management practices is also available through 'Infopest'.

I wish to compliment the work of Mr D.M. Persley, Mr R. G. O'Brien, Dr J. R. Syme in editing this volume. I also gratefully acknowledge the assistance from staff of Standards and Information Branches in providing data and organizing the publication of this volume.

I. F. Muirhead
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Glossary

Anthracnose - a disease usually characterised by depressed spots lined with pink spore masses during moist conditions. Characteristic of infection by the fungus *Colletotrichum*.

Apothecium (pl. apothecia) - a cup or saucer-shaped fungal structure in which spores are carried.

Ascospore - a fungal spore formed during the sexual stage of certain fungi. An ascospore is carried in a sac-like structure called an ascus. Ascospores are often the initial disease inoculum at the beginning of a season.

Chlamydospore - a thick walled resting spore of a fungus which allows survival during adverse conditions.

Chlorosis - a yellowing or absence of normal green colour from plant parts.

Conidium - (pl. conidia) - fungal spore produced during the non-sexual stage of the life cycle. Allows fungal dispersal, often with aid of wind or water.

Cotyledons - seed leaves. The first leaves appearing after seed germination and having an important role in the early stages of seedling development.

'Fired' - rapid browning and death of leaves.

Fruiting body - general term for spore bearing structures of fungi.

'Lugs' - old seed leaves of, for example, bean plants.

Lenticel - a minute hole or pore in the stem or fruit

allowing gas exchange. Often a point of entry for bacteria.

Necrosis - death of plant cells and tissues.

Pathogen - a parasite able to cause disease in a host plant. The major groups of plant pathogens are fungi, bacteria, nematodes and viruses.

Phytotoxic (phytotoxicity) - a substance toxic to plants. For example, excessive rates of pesticides or fertiliser.

Race - a subgroup within a species which can be distinguished by certain characteristics such as symptoms or the ability to infect certain varieties or hosts.

Sclerotia - small, hard, dark fungal structures. They can remain dormant in the soil for long periods and germinate upon the return of favourable conditions. They are an important means of survival for some fungal pathogens, for example *Sclerotium rolfsii*.

Senescent - old

Spore - a minute propagative unit of a fungus which functions as a seed.

Sporulation - production of spores by a fungus.

Stolons - a long, slender, modified stem which produces new plants.

Suture - a junction line where plant tissues are joined.

w/w - weight to weight - a proportion by weights.

Beans - French

FIELD DISEASES

Bacteria and mycoplasmas

Bacterial brown spot

Pseudomonas syringae pv. *syringae*

Symptoms

Leaves: small tan spots with reddish-brown margins. These are generally circular but sometimes angular when bordered by veins. There is often a very narrow lemon-green halo around each spot. With time, the central part of the spot may fall out giving the leaves a ragged appearance.

Stems: tan spots up to 10 mm in diameter with reddish-brown margins.

Pods: at first, dark green circular water-soaked spots which enlarge and become sunken and tan with distinctive reddish-brown margins. Pods sometimes bend sharply at the spots.

Source of infection and spread

The use of infested seed is the most important means of introducing the disease. Seed contamination comes from direct pod infection or contact of the seed coat with plant debris during harvesting and handling.

Showery weather helps infection. Once the disease is established, wind, rain and the movement of workers, machines and animals through the wet crop favour disease spread. The bacterium often enters leaves through rust pustules and hail-damaged areas. It survives on undecomposed crop residues.

Importance

Occurs sporadically and is often serious.

Control

1. Use disease-free seed; for example, certified or approved seed.
2. Avoid movement of workers and machinery between diseased and disease-free areas of the crop, particularly when wet.
3. Copper sprays slow disease development.
4. Plough-in diseased crops immediately after harvesting.
5. Avoid susceptible cultivars.

Common blight

Xanthomonas campestris pv. *phaseoli*

Symptoms

Leaves: small angular water-soaked spots which coalesce to form large brown dead areas, commonly with bright yellow margins.

Stems: dark green streaks, at first water-soaked, then tan.

Pods: small water-soaked spots with yellow ooze in the centre. These later become sunken and reddish-brown. Difficult to distinguish from halo blight.

Source of infection and spread

The use of infested seed is the most important means of introducing the disease. Seed contamination comes from direct pod infection or contact of the seed coat with plant debris during harvesting and handling.

Warm showery weather helps infection. Once the disease is established, wind, rain and the movement of workers, machines and animals through the wet crop favour disease spread.

The bacterium survives on undecomposed crop residues.

Importance

Major.

Control

1. Use disease-free seed; for example, certified or approved seed.
2. Avoid movement of workers and machinery between diseased and disease-free areas of the crop, particularly when wet.
3. Copper sprays slow disease development.
4. Plough-in diseased crops immediately after harvesting.

Halo blight

Pseudomonas syringae pv. *phaseolicola*

Symptoms

Leaves: small tan angular greasy spots surrounded by a wide diffuse lemon-green halo which is sometimes difficult to detect during hot weather. A strain of this bacterium occurring in Queensland produces halo-less spots.

Invasion of the water-conducting system may cause wilting, yellowing of the leaves, stunting and death of the plant.

Stems: elongated dark green water-soaked areas.

Pods: circular dark green water-soaked spots in the centres of which a pearly white to cream ooze develops. These spots, commonly called 'grease spots', eventually become slightly depressed and rusty brown in colour. Difficult to distinguish from common blight.

Source of infection and spread

The use of infested seed is the most important means of introducing the disease. Seed contamination comes from direct pod infection or contact of the

seed coat with plant debris during harvesting and handling.

Cool showery weather helps infection. Once the disease is established, wind, rain, and the movement of workers, machines and animals through the wet crop favour disease spread.

Susceptible tropical legumes, particularly siratro (*Macroptilium purpureum*), glycine (*Glycine wightii*) and phasey bean (*Macroptilium lathyroides*) may provide a source of infection for nearby bean crops. The bacterium survives on undecomposed crop residues.

Importance

Major.

Control

As for common blight (see p. 1)

Little leaf

Mycoplasma-like organism

Symptoms

Affected plants develop numerous spindly secondary shoots with small leaves. Flowers may be distorted with green petals. Affected plants may fail to produce pods. If pods are present, they are generally distorted.

Source of infection and spread

The organism is spread by leafhoppers. The pathogen has a wide range of hosts among crop and weed species.

Importance

Minor.

Control

Not warranted.

Pod twist

Pseudomonas flectens

Symptoms

Water-soaked areas on young pods, which may wither and fall. Those that remain enlarge but retarded development of the affected areas leads to curling and bending of the pods. Droplets of milky exudate appear on the water-soaked areas. These dry to leave a shiny encrustation. Affected areas darken in colour.

Source of infection and spread

The main sources of the bacterium are diseased French beans and phasey bean (*Macroptilium lathyroides*). The bacterium is spread from plant to plant by the bean blossom thrip (*Megalurothrips usitatis*). The insect alone can cause considerable twisting and scarring of pods.

Pod twist is confined to the warmer months of the year and is a minor problem in commercial bean crops which mature in the cooler months.

Importance

Minor.

Control

1. Apply insecticides at flowering to control thrips.
2. Plough-in diseased crops immediately after harvesting.

Fungi

Angular leaf spot

Phaeoisariopsis griseola

Symptoms

Leaves: circular spots up to 10 mm in diameter, often with a zonate or target appearance, on primary or shield leaves. Spots on the trifoliate leaves are smaller, up to 3 mm wide and angular. Small black clusters of bristles (fruiting bodies) are generally visible on the spots on the undersides of the leaves.

Pods: dark sunken patches of varying size, often with diffuse margins.

Source of infection and spread

The use of infested seed is the most important means of introducing the disease. Seed contamination comes from direct pod infection or contamination of the seed coat by plant debris during harvesting.

Rapid spread of the disease occurs during wet windy weather. The fungus also survives on undecomposed crop residues.

Importance

Minor in well-sprayed crops.

Control

1. Plant resistant cultivars, for example, a Redlands Greenleaf cultivar.
2. Plough-in diseased crops immediately after harvesting.
3. Apply the recommended fungicide mancozeb at 7 to 10-day intervals as required.

Anthracnose

Colletotrichum lindemuthianum

Symptoms

Leaves: dark streaks on veins on the undersides.

Pods: dark brown sunken spots, the centres of which become covered with pink waxy spores during moist weather.

Source of infection and spread

The use of infested seed is the most important means of introducing the disease. Seed contamination comes from direct pod infection or contact of the seed coat with plant debris during harvesting and handling.

Once the disease is established; wind, rain, and the movement of workers, machines and animals

through the wet crop favour disease spread. The fungus survives on undecomposed crop residues.

Importance

Rare with the widespread use of approved seed.

Control

1. Use disease-free seed; for example, certified or approved seed.
2. Avoid movement of workers and machinery between diseased and disease-free areas of the crop, particularly when wet.
3. Plough-in diseased crops immediately after harvesting.

Ascochyta spot

Ascochyta phaseolorum

Symptoms

Leaves: circular grey to brown spots often marked by concentric rings and with a well-defined dark brown margin. Most spots are 6 to 12 mm wide but may reach 25 mm under very favourable conditions. The centres of spots eventually dry and crack leaving ragged holes. Many small black fruiting bodies of the fungus may be seen embedded in affected tissues.

Pods: large dark spots, mostly occurring around injuries. Infection of the floral remnants causes a dark dry rot of the pod extending from the stem-end.

Source of infection and spread

The fruiting bodies produced on diseased plants contain large numbers of spores which are spread by splashing water. Plants grown in locations exposed to wind are very susceptible to attack, the fungus entering through damaged leaves and pods. However, spots may also develop around rust pustules, insect feeding sites and other injuries.

A number of tropical legumes provide a source of spores for nearby bean crops. The fungus may also be carried on the seed.

Importance

Rare.

Control

1. Establish windbreaks in exposed locations.
2. Keep rust and insect pests under control.
3. Avoid planting beans adjacent to tropical legume pastures.

Ashy stem blight

Macrophomina phaseolina

Symptoms

Seedlings: a small black sunken sharply defined spot develops on the stem at the base of the old seed pieces. The spot may extend in either direction along the stem and often the growing tip is killed. Characteristically, the rot occurs on one side of the stem. Seedlings are eventually killed.

Plants: older plants may show similar diseased areas with symptoms being more pronounced on one side of the plant. These areas have a dark margin and often some concentric markings. An ashy-grey centre develops and small black resting bodies may be seen. Affected plants eventually die.

Source of infection and spread

The fungus survives in the soil for long periods. Serious outbreaks occur during hot dry weather.

Importance

Minor.

Control

Plant on good soil moisture and maintain good growing conditions.

Cercospora leaf spot

Cercospora canescens

Symptoms

Circular or slightly angular greyish spots, sometimes with reddish margins, on senescing (dying) leaves only.

Importance

Minor. Seen only on senescing leaves.

Control

Not warranted.

Cottony leak

Pythium aphanidermatum

Symptoms

Leaves and stem: soft water-soaked areas with fine white cottony growth in wet weather. The fungus may also cause damping-off of seedlings and root rot of mature plants.

Pods: watery soft rot in transit or storage. Abundant white cottony growth mats pods together into 'nests' which later become a soft leaking mass known as cottony leak.

Source of infection and spread

The fungus is a soil-inhabiting water mould; warm wet weather favours its development.

Importance

Generally minor but may cause appreciable losses in hot weather. The stem rot phase may cause thinning of stands.

Control

Stem rot in the field.

1. Avoid close planting.
2. Cultivate carefully to avoid plant injury.
3. Do not plant poorly drained areas.
4. Prepare land thoroughly to allow residues to decompose.

Cottony leak.

1. Discard diseased pods and pack dry.
2. Store in well-ventilated areas at a temperature of 12 to 15°C.

Grey mould

Botrytis cinerea

Symptoms

Pods and stems become water-soaked then wilt and die. Affected areas are covered with a grey powdery mass of spores. Pods touching the ground often develop a rot which leads to considerable loss in transit.

Source of infection and spread

The disease is favoured by cool humid weather.

Importance

Minor. Serious outbreaks of the disease are rare.

Control

The spray programme recommended for Sclerotinia rot will give some control of this disease (see p. 5).

Pleiochaeta brown spot

Pleiochaeta setosa

Symptoms

Leaves: reddish-brown spots rarely more than 2 mm wide, the centres of which eventually fall out leaving ragged holes. Small dark spots are often produced on veins on the underside of the leaves.

Pods: slightly sunken spots with dark centres and light brown margins. These range up to 2 mm wide and may coalesce.

Source of infection and spread

This disease is restricted to areas where beans are grown on very light sandy soils. The fungus is a wound pathogen only, and leaf and pod abrasion by sand during strong winds predisposes plants to attack.

Streaked rattlepod (*Crotalaria pallida*) and Gambia pea (*Crotalaria goreensis*) are alternative hosts of the fungus.

Importance

Rare. A problem only in wind-damaged crops on sandy soils.

Control

1. Eradicate alternative weed hosts.
2. Establish windbreaks in exposed locations.

Red root complex

Fusarium solani f. sp. *phaseoli*, *Aphanomyces* sp. and *Pythium* sp.

Symptoms

Pronounced reddening and dying of the tap-root which may be completely destroyed. Plants generally

produce a cluster of fibrous roots just below ground level and, if growing conditions are good, may recover and crop satisfactorily. Affected plants are yellow and stunted and yields may be reduced considerably.

Source of infection and spread

The fungi causing red root are soil inhabitants favoured by low soil temperatures and wet soil conditions. The disease is often severe in light sandy soils where beans have been grown continuously for many years.

Importance

Can cause serious losses where monoculture is practised, particularly in cold wet winters.

Control

1. Deep rip to improve drainage and aid root penetration.
2. Avoid deep planting, sow at 25 mm during winter months.
3. Hill plants to encourage new root growth.

Rhizoctonia rot

Rhizoctonia solani

Symptoms

Stem: sunken brick red areas on the lower stem and roots often before seedlings emerge. Some plants are killed, others remain stunted, but many recover to give a satisfactory crop after producing new roots above the diseased area.

Pods: reddish spots where pods are in contact with the soil. The fungus spreads rapidly during transit, often with a brown fungal growth appearing on affected areas.

Source of infection and spread

The fungus is a common soil inhabitant affecting a wide range of plants. The disease is often severe in areas which have recently grown potatoes and crucifers and in soils with large amounts of plant residue.

Importance

Minor seedling disease but can be serious in pods to be processed.

Control

1. Prepare land thoroughly so that plant residues are completely broken down before planting.
2. Avoid planting beans immediately after crucifers and potatoes.
3. Treat seed with the recommended fungicides.
4. Hill plants to encourage new root growth.

Rhizopus soft rot

Rhizopus stolonifer

Symptoms

A watery soft rot of pods which are joined together by fluffy grey white fungal growth in which large numbers of small black stalked fruiting bodies form. A sour acid odour is often present.

Source of infection and spread

Warm humid conditions favour development of the rot. Infection occurs mainly through wounds.

Importance

Minor.

Control

The post-harvest treatment recommended for Sclerotinia rot will also control this disease (see p. 5).

Rust

Uromyces appendiculatus

Symptoms

Leaves and stem: small circular yellow spots, from the centres of which reddish-brown powdery spores develop. When the disease is severe, leaves yellow, wither and fall. During cold weather, spore masses may be black rather than red.

Pods: similar spots to those on leaves and stem but spores may not always be obvious. Often all that shows are small raised firm water-soaked blisters.

Source of infection and spread

Large numbers of spores produced on leaf and pod spots are spread by wind. Infection is favoured by cool, damp weather; fogs, mists and dews provide ideal conditions.

The disease is most severe in areas where old diseased crops are left standing after harvesting has been completed.

A number of races of the fungus, differing in their ability to attack bean cultivars, are present in Queensland.

Importance

Can be serious but can be controlled by spraying.

Control

1. Spray with the recommended fungicides.
2. Plough-in crops immediately after harvesting.
3. Use resistant cultivars, for example, Redlands Greenleaf cultivar.

Fungicides

Mancozeb, maneb, metiram, zineb - use sufficient spray to provide good coverage.

1. Where consecutive plantings are made, spray every 7 to 10 days beginning at emergence.
2. In other areas, two sprays before flowering should suffice provided the sprays are applied at the first and third trifoliate leaf stages.

Chemical: oxycarboxin.

Apply at first sign of disease and again 14 days later.

Sclerotinia rot

Sclerotinia sclerotiorum

Symptoms

A brown watery soft rot of the stem, leaves and pods with masses of white fluffy fungal growth. Large irregular black resting bodies (sclerotia) form in the rotted tissues.

The disease may also develop in pods in transit and storage (Sclerotinia nest).

Source of infection and spread

The sclerotia of the fungus can survive in the soil for many years. They are continually being buried and brought to the surface by cultural operations. Those in the top 100 mm of soil germinate under cool moist conditions to produce at the soil surface small cream 'mushroom-like' bodies called apothecia. These contain large numbers of spores which are forcibly discharged and carried by wind over many kilometres.

Before this fungus can attack a healthy plant, the spore must first germinate on and infect dying plant material. In the bean plant, the old seed leaves ('lugs' or cotyledons) and the spent blossoms are suitable sites.

The old lugs generally fall close to the base of the stem. The fungus infects these and grows into the stem causing a base rot from which the plant rarely survives.

Spent blossoms fall and lodge on leaves, pods or in the leaf axils from which the fungus can quickly invade neighbouring tissues.

Sclerotinia rot is favoured by cool showery weather but fogs, mists, dews and irrigation provide enough moisture for infection to occur. The disease is more serious in low areas of fields and along creek banks where mists and fogs tends to lie and keep the plants wet well into the morning.

Many cultivated plants are susceptible to Sclerotinia rot.

Importance

More prevalent in the cooler months but can be controlled by spraying.

Control

1. Spray with the recommended fungicides. Timing of sprays is critical.
2. Discard diseased pods and use the recommended post-harvest treatment.
3. Plough-in diseased crops immediately after the final harvest.

Fungicides

Chemical: benomyl plus a wetting agent, or vinclozolin.

1. Spray when 10% of plants first show open blossom and again seven days later.

2. A spray just before the cotyledons start to turn yellow may help to control the basal stem rot phase of this disease.

Fungicide dip

Chemical: dicloran

1. Dip pods using wire baskets or perforated tins, not bags or cases.
2. Keep the dip agitated during use.
3. After dipping, thoroughly drain the beans to avoid undesirable yellow deposits.
4. Top up to the original volume regularly with a suspension of the same strength as the original dip.
5. Discard the dip at the end of each day or sooner if it becomes contaminated with dirt and trash.

Sclerotium crown rot

Sclerotium rolfsii

Symptoms

Stem: a pale dry rot of the lower stem and roots with white thread-like fungal growth on the surface. In moist conditions, this growth is very conspicuous and often spreads out over the soil surface in fans. Small brown spherical resting bodies (sclerotia), about the size of cabbage seed, develop among the white growth.

Pods: a rot similar to that on stems develops on pods in contact with the soil.

Source of infection and spread

The fungus is a common soil inhabitant which affects a wide range of plants. It is favoured by high temperatures and large amounts of plant residues in the soil.

Importance

Minor.

Control

Prepare land thoroughly so that residues are completely broken down.

Nematodes

Root-knot nematodes

Meloidogyne spp.

Symptoms

Galls or swellings on roots. Severely affected plants may be stunted and pale in colour and wilt readily on hot days.

Importance

Minor.

Control

Not warranted.

Viruses

Bean yellow mosaic

Bean yellow mosaic virus

Symptoms

Leaves show a yellowish mottle which is generally more intense than that produced by bean common mosaic virus.

Source of infection and spread

The virus is spread by aphids. It is relatively uncommon in beans and is generally seen only in crops adjacent to affected gladioli plants which are a common host of the virus.

Importance

Minor.

Control

Not warranted.

Common mosaic

Bean common mosaic virus

Symptoms

Cupping and twisting of leaves with a light and dark green mosaic pattern. The dark green tissue is often bubbled and/or in bands next to the veins. Affected plants produce smaller curled pods with a greasy appearance. Yields are reduced.

Source of infection and spread

The virus may be carried in the seed and is spread by aphids. Other legumes may also carry the virus.

Importance

Can be serious when diseased seed is planted.

Control

Use disease-free seed; for example, certified or approved seed and resistant cultivars.

Stipple streak

Tobacco necrosis virus

Symptoms

Leaves: red-brown streaks on the veins bordered by bright yellow areas. Brown streaks are often seen on the leaf stalks and stem.

Pods: dark brown dead areas, some of which resemble ringspots. Dark brown streaks are also produced along the sutures.

Source of infection and spread

The virus, which has a wide host range, is transmitted by spores of the soil-borne fungus *Olpidium brassicae*.

Importance

Rare.

Control

Not serious enough to warrant control measures.

Beetroot

FIELD DISEASES

Fungi

Aphanomyces root rot

Aphanomyces cochlioides

Symptoms

A dark brown to black discolouration of the tap-root of young plants. Leaves commonly turn red.

In older plants, large roughly circular depressed dark lesions occur on the globe.

Source of infection and spread

The fungus is soil-borne. Infection and disease development is favoured by warm weather and high soil moisture.

Importance

Serious in poorly drained areas.

Control

Avoid poorly drained areas. Provide good seedbed tilth.

Damping-off

Pythium spp.

Symptoms

A soft decay of the tap-root with a resultant collapse of the seedling.

Source of infection and spread

The fungi are water moulds and thrive in wet soils. Consequently, the disease is generally more common in low-lying sections of fields.

Importance

Serious in poorly drained areas.

Control

Use the recommended fungicides.

Fungicide seed treatment

Dust the seed with metalaxyl (350 g/kg) at the rate of 200 g/100 kg seed before planting.

Leaf spot

Cercospora beticola, *Phoma betae*

Symptoms

Cercospora leaf spot: small brown flecks with a reddish border expanding to circular spots about 4 mm wide with an ashy-grey centre. This often drops out leaving a ragged hole.

Phoma leaf spot: large light brown spots often with concentric markings. Small black fruiting bodies form on old spots.

Source of infection and spread

The fungi survive on undecomposed beet residues in the soil but may also be carried on the seed. Spores are spread rapidly during wet windy weather. The disease is favoured by warm wet weather.

Importance

Minor in well-sprayed crops.

Control

Use the recommended fungicide treatment. The disease is favoured by warm wet conditions.

Fungicides

Chemicals: mancozeb or zineb at recommended label rates.

Sclerotium base rot

Sclerotium rolfsii

Symptoms

A soft rot of the fleshy root, affected areas being covered with white fungal growth in which small brown spherical resting bodies (sclerotia) form.

General

The disease is mainly a warm weather problem.

Importance

Minor.

Control

Ensure that all plant residues are thoroughly decomposed before sowing.

Nematodes

Beet cyst nematode

Heterodera schachtii

Symptoms

Plants are stunted and often develop large numbers of fine 'feeder' roots. Female nematodes can be seen as small white cysts on the plant roots. The next generation develops as eggs within the female body which changes to a brown colour as it develops into a mature cyst.

Source of infection and spread

The nematode survives in soil as the egg stage within the cyst. Cysts can be distributed with soil in run-off water and on farm machinery, workers and animals.

Importance

Minor. Nematode has a limited distribution.

Control

1. Do not plant beetroot or crucifers on infested land for at least three years.
2. Treat the soil 1 to 7 days before planting with fenamiphos spray at recommended label rates.

Root-knot nematodes

Meloidogyne spp.

Symptoms

Galls or swellings on main and secondary roots. Heavily infested plants are usually stunted with the main root malformed.

Source of infection and spread

Root-knot nematodes are common, even in virgin land. Eggs and larvae are spread in soil in run-off water or adhering to farm machinery, workers or animals.

Importance

Minor, as most crops are now grown on heavy soils.

Control

1. Crop rotation.
2. Treat the soil 1 to 7 days before planting with fenamiphos spray at recommended label rates. **This chemical is extremely dangerous. Follow safety directions on label.**

Capsicums

FIELD DISEASES

Bacteria and mycoplasmas

Bacterial canker

Corynebacterium michiganense pv. *michiganense*

Symptoms

Leaves: pale green raised areas which develop into irregular corky pustules with a brown centre. The old pustules tend to collapse leaving slightly raised, irregular brown areas. Affected leaves fall readily.

Fruit: small raised white circular spots with a tan centre. Similar to the 'bird's eye' spot caused by this bacterium on tomato fruit.

Source of infection and spread

The bacterium may be introduced on the seed or spread from nearby diseased tomato plants.

Importance

Rare.

Control

Use hot-water treated seed. Refer to seed treatment for bacterial spot control.

Bacterial spot

Xanthomonas campestris pv. *vesicatoria*

Symptoms

Leaves: tan-coloured translucent spots up to 5 mm in diameter with dark brown margins. Affected leaves fall readily and, in favourable conditions, spots may coalesce to cause leaf blight.

Fruit: dark brown to black scabs often concentrated on the shoulders of the fruit. This symptom is uncommon.

Source of infection and spread

The bacterium is commonly introduced in seed. Once established in a plant, it is then spread during wet windy weather and by overhead irrigation. Warm humid weather favours disease development.

The bacterium also affects tomatoes. The bacterium may survive on undecomposed tomato or capsicum residues in the soil.

Importance

Serious, particularly in wet weather.

Control

1. Spray with recommended chemicals.
2. Destroy old tomato and capsicum crops promptly.
3. Use resistant cultivars if available.

Fungicides

Seedlings: mancozeb plus copper oxychloride. Begin when the first true leaves have formed and continue at seven-day intervals until transplanting.

Field chemicals: mancozeb plus copper oxychloride. Use sufficient spray to give good coverage. Spray at a maximum of 14-day intervals. Spray more regularly if prolonged wet weather occurs. Attempt to anticipate wet weather and spray before it.

Seed treatment (for control of seed-borne bacterial spot and bacterial canker)

Treat seed in hot water at 50°C for 30 minutes. This treatment may reduce the germination of old seed or seed lacking vigour. Sow as soon as possible after treatment. Dust treated seed with thiram at the rate of 2 to 3 g/kg seed to prevent seed rot. Remember to screen off excess dust. Plant into a fumigated seedbed or sterile potting mix.

Seedbed fumigation

Treat soil with methyl bromide. Before treatment, ensure that soil is free from undecomposed organic matter.

Bacterial wilt

Pseudomonas solanacearum

Symptoms

A sudden wilting of the foliage which is particularly evident during the hot part of the day. Stunting of the plant frequently precedes the wilting. When the stem is cut across at ground level, the water-conducting tissues just beneath the bark will be discoloured brown.

Source of infection and spread

The bacterium is a soil inhabitant and is particularly active in hot wet weather. It may survive from season to season on undecomposed tomato and capsicum residues and by invading a number of common weeds. Once established, the organism spreads rapidly through the crop by irrigation and rain water, particularly down slopes. Plant-to-plant spread may also occur by root contact.

Importance

Minor.

Control

Avoid planting into known infested areas.

Fungi

Alternaria fruit rot

Alternaria sp.

Symptoms

On fruit, dark sunken spots up to 30 mm wide. Sometimes confused with blossom-end rot which it often follows.

General

The fungus enters mainly through injuries to the skin. It may also develop during transit.

Importance

Minor.

Control

Spray with recommended fungicides.

Fungicides

Field chemicals: mancozeb plus copper oxychloride.

Use sufficient spray to give good coverage. Spray at a maximum of 14-day intervals. Spray more regularly if prolonged wet weather occurs. Attempt to anticipate wet weather and spray before it.

Anthracnose

Colletotrichum acutatum. *Colletotrichum capsici* may occasionally be involved.

Symptoms

Circular sunken spots on ripening fruit. In moist weather, pink spore masses form on the spots.

Source of infection and spread

Large numbers of spores produced on fruit spots are spread to healthy fruit during wet windy weather. Although infection may occur at any stage of fruit development, symptoms do not show until ripening.

Importance

Minor.

Control

Spray with the recommended fungicides. May be seed-borne. Do not save seed from affected crop.

Fungicides

As for Alternaria fruit rot (see above).

Grey mould

Botrytis cinerea

Symptoms

Pale ring-like spots on fruit. Similar symptoms are produced by the same fungus on tomatoes. Green vegetable bug damage to capsicum fruit may resemble grey mould symptoms.

Importance

Rare.

Control

Not warranted.

Powdery mildew

Leveillula taurica

Symptoms

A white powdery growth on leaves and sometimes stems.

Source of infection and spread

Spores of the fungus are air borne and the disease is favoured by dry weather.

Importance

A common disease in the dry tropics, occasionally severe elsewhere.

Control

Spray with recommended fungicides.

Fungicides

Chemicals: benomyl, wettable sulphur.

Begin when the disease is first seen and continue at 10 to 14-day intervals as required.

Sclerotinia rot

Sclerotinia sclerotiorum

Symptoms

A white cottony fungal growth on stem and branches causing the plant to collapse. Large black irregular resting bodies (sclerotia) develop in the white fungal growth. Affected areas later become bleached. The stem may be girdled causing the plant to die.

Source of infection and spread

The disease is generally serious only when capsicums are grown in infested soils in winter and prolonged periods of wet weather occur. Spores arising from the sclerotia in the soil infect dying flower parts trapped in the bush or on the ground around the base of the stem. Healthy tissue in contact with these flowers is then invaded.

Importance

Minor.

Control

1. This disease affects several other crops. Avoid planting known infested areas in the cooler months.
2. Spray with recommended fungicide (benomyl) as soon as disease is observed.

Stem rot

Sclerotium rolfsii

Symptoms

The plant wilts and stem tissues at the soil line and above are discoloured brown. A thick white cottony fungal growth is usually present on affected stem tissues. The presence of brown fungal sclerotia about the size of mustard seeds confirms the identification of the disease.

Source of infection and spread

The organism has a large host range and affects many other vegetable crops. The fungus survives in the soil as sclerotia. With warm moist conditions these germinate and infect plants.

Importance

Common. Plastic mulching usually increases the incidence of stem rot by providing suitable environmental conditions.

Control

Avoid rotations with tomatoes, beans and potatoes which are also susceptible, particularly on land where the disease is known to occur.

Undetermined

Sudden wilt

Symptoms

Although the cause of the disease is undetermined, *Pythium* spp. and *Fusarium* spp. are usually present in the roots of affected plants.

A sudden wilt of foliage as plants reach the stage of rapid fruit enlargement. Up to this stage plants appear healthy. One or more large roots and most feeder roots are discoloured brown.

Source of infection and spread

The fungus *Pythium* spp. is thought to be the primary cause of this disease. It is present in soil and spread with running water. The sudden wilting of foliage is due to root destruction at a time when the plant needs a lot of water.

Importance

Occurs sporadically; occasionally severe, particularly in warm weather.

Control

1. Avoid planting on poorly drained soil.
2. Ensure seedlings are disease-free.

Viruses

Mosaic

Potato virus Y

Symptoms

Leaves puckered with narrow discontinuous bands of dark green tissue along the main veins. This contrasts with areas of abnormal yellow-green tissue between the veins. Affected plants are stunted and yields are reduced. Some fruit may be malformed.

Source of infection and spread

Mosaic is caused by the same strain of potato virus Y which produces leaf shrivel in tomatoes and vein necrosis in tobacco. It is spread to capsicums by several species of aphid from diseased tomatoes or tobacco and susceptible weeds.

Importance

Serious in susceptible cultivars.

Control

1. Use resistant cultivars.
2. Sanitation. Destroy old infected capsicum and tomato crops. Ratooning of capsicum favours disease increase.

Cultivar reaction to mosaic

Three strains of potato virus Y occur in Queensland. Cultivars highly resistant to strain 1 include Bell Tower, Cordoba, David, Skipper, Northern Bell Improved and Redlands Sweet Sue. Of the cultivars listed above only Cordoba is highly resistant to strain 2. Improved Northern Bell and Redlands Sweet Sue are susceptible while the other cultivars listed are moderately resistant. None of the currently available cultivars are resistant to strain 3.

Spotted wilt

Tomato spotted wilt virus

Symptoms

Leaves: yellowish, parallel line or concentric ring patterns. Young shoots may be blighted but normal growth often resumes later.

Fruit: yellow rings and blotches, up to 10 mm wide with normal coloured tissue surrounding. These may not show until the fruit begins to ripen.

Source of infection and spread

The virus is common in many plants and weeds and is spread by thrips.

Importance

Minor.

Control

1. Keep the crop and headlands free from weeds.
2. Destroy affected plants.

POST-HARVEST

Soft rot

Erwinia carotovora pv. *carotovora*

Symptoms

A soft wet rot of fruit. Early symptoms may show as a brown discolouration of the tissues of the stem end.

Source of infection and spread

The disease is mainly a post-harvest problem and is rarely seen in the field. The bacterium enters the fruit through the cut stem and at injuries, and advances rapidly into surrounding tissues. The disease is worst in fruit harvested in hot wet weather.

Importance

Minor.

Control

1. Maintain good control of insect pests which provide wounds for bacteria to enter.

2. Avoid harvesting while plants are wet.
3. Handle fruit carefully to avoid damaging the skin.
4. Cool fruit promptly after harvest.
5. Use the recommended post-harvest treatment.

Post-harvest treatment (use only where bacterial soft rot is a serious problem).

Dip fruit immediately after harvest in a sodium hypochlorite solution containing at least 100 ppm available chlorine; for example, a commercial bleach concentrate containing 100 g available chlorine/L should be diluted at the rate of 100 ml to 100 L of water. As the chlorine dissipates due to interaction with organic matter and high temperatures, a check on the level of available chlorine should be made at regular intervals with a test kit. Additional chlorine should be added if the concentration falls below 50 ppm. A wetting agent should be added to ensure thorough wetting of the fruit. Dip for one minute and allow fruit to dry thoroughly before packing. Where available, cool storage is also recommended. Field spraying as recommended for bacterial spot may reduce this problem.

Carrots

Fungi

Damping-off

Pythium spp., *Rhizoctonia solani*

Symptoms

A soft decay of the taproot with a resultant collapse of the seedlings. Surviving plants may develop 'forking' of roots as a result of root damage.

Source of infection and spread

The fungi are common soil inhabitants. Infection is more likely to occur in cold wet weather, in poorly drained fields or in areas where the crop is grown intensively.

Importance

Can cause substantial reduction in plant stands, particularly in fields where carrots grow intensively.

Control

1. Treat seed with the recommended fungicidal dusts.
2. Do not plant into soil containing undecomposed plant trash.

Fungicide dusts

Chemicals: metalaxyl, quintozene.

1. Mix the metalaxyl seed dust preparation with quintozene in the ratio of 1:1.
2. Apply the dry mixture to seed at the rate of 2 g per kg of seed.

Fusarium root rot

Fusarium solani

Symptoms

A shallow black spongy decay of the fleshy tap-root often occurring at the points of emergence of the small fibrous roots. Whitish fungal growth may be visible on affected areas.

General

The disease is mainly a problem in warm weather where the plant has been stressed. The rot may also develop extensively in storage.

Importance

Rare.

Control

Manage crops to minimise plant stress.

Leaf spot

Alternaria dauci, *Cercospora carotae*

Symptoms

Dark grey to brown, angular spots on leaves. Surrounding tissues yellow and affected leaves eventually die. Older leaves are attacked first by *Alternaria dauci* and only in severe cases are younger leaves affected. However, with *Cercospora carotae*, the young leaves are often first affected.

Source of infection and spread

The fungi survive on undecomposed carrot residues in the soil but may be introduced on the seed. Spores produced on the leaves are spread rapidly during wet windy weather.

Importance

Can be serious in wet seasons but may be controlled by spraying.

Control

Spray with recommended fungicides.

Fungicides

Chemicals: Mancozeb, maneb + zineb, metiram, zineb, chlorothalonil.

Begin at the first sign of the disease and continue at 10 to 14-day intervals as required.

Root and crown rot

Rhizoctonia solani, *Sclerotium rolfsii*

Symptoms

Sclerotium rolfsii: soft water-soaked areas on the fleshy root becoming covered with white fungal growth in which small brown spherical resting bodies (sclerotia) form.

Rhizoctonia solani: brown, slightly sunken spots on the fleshy taproot.

General

The diseases are mainly a problem in summer. They may also develop extensively in storage.

Importance

Occasionally serious.

Control

Ensure that all plant residues are thoroughly decomposed before sowing.

Sclerotinia rot

Sclerotinia sclerotiorum

Symptoms

A wet rot of leaves, crowns and roots. Affected areas later become covered with masses of white cottony

fungal growth in which large black irregular, resting bodies (sclerotia) form.

Source of infection and spread

The sclerotia enable the fungus to survive for long periods in the soil. During cool moist weather, those near the surface germinate to produce at the soil surface small cream apothecia. These contain large numbers of ascospores which are forcibly discharged and carried by wind over long distances. Before the fungus can invade healthy tissues, the spore must first germinate on and infect dead or dying plant material. It then invades healthy tissues in contact. Cool showery weather favours the fungus but fogs, mists, dews and irrigation provide enough moisture for infection to occur.

If diseased roots are packed, extensive breakdown may occur during transit and storage.

A large number of other crops and weeds are susceptible to Sclerotinia rot.

Importance

Can be serious in leafy crops in cool weather.

Control

1. Do not plant carrots in badly infested areas during the cooler months.
2. Do not pack damaged roots.

Fungicides

Chemicals: Benomyl and vinclozolin

1. A maximum of three sprays may be necessary but at least one must be made before the canopy closes. Apply sprays at 14-day intervals.
2. For optimum coverage, nozzles should be dropped into the inter-row space.

Nematodes

Root-knot nematodes

Meloidogyne spp.

Symptoms

Galls or swellings on the fleshy tap-root.

Importance

Important in many crops grown on light soils.

Control

Treat the soil with a recommended nematicide before planting.

Preplant fumigation (for control of root-knot nematodes when planting infested areas)

Apply one of the following soil treatments:

- (a) Treat the soil with EDB at the recommended label rates.
- (b) Apply fenamiphos spray at the rate of 24 L in 150 to 300 L of water/ha one to seven days before planting. Use a boom spray at 150 to 200 kPa as an overall treatment.

Apply while the soil is moist after rain or irrigation and immediately incorporate to

100 mm with a rotary hoe or discs. **Read labels carefully. This nematicide is extremely dangerous.**

Viruses

Motley dwarf

Carrot mottle virus and carrot red leaf virus

Symptoms

Affected plants lose vigour and become pale and distorted. Symptoms are most serious in winter when the tops are dwarfed and flattened against the ground showing prominent yellow and purple colourations. Yield is reduced. During summer, effects are less severe.

General

The virus complex is transmitted by aphids. The disease is uncommon as many commonly grown cultivars are resistant.

Importance

Minor.

Control

Not warranted.

POST-HARVEST

Soft rot

Erwinia carotovora pv. *carotovora*

Symptoms

A soft sunken rot of fleshy roots, generally around the points of emergence of fibrous roots.

Source of infection and spread

The disease is mainly a problem in transit and storage but, after prolonged wet weather, may occur in the field. It is readily spread in washing water and may develop extensively if carrots are then stored under warm humid conditions. The bacteria enter through wounds.

Importance

Can cause serious losses under poor storage conditions.

Control

1. Discard affected carrots before transport and storage.
2. Use the recommended bactericide in the wash water.

Post-harvest treatment (where bacterial soft rot is a serious problem) Add sufficient sodium hypochlorite to the wash water to obtain a concentration of 50 to 100 ppm of available chlorine; for example, a commercial bleach concentrate

containing 100 g available chlorine/L should be diluted at the rate of 50 to 100 mL to 100 L of water. As the chlorine content dissipates due to interaction with organic matter and light, a check of the level of

available chlorine should be made at regular intervals with a test kit. A fresh solution should be prepared each day. Cool storage is also recommended where available.

Celery

FIELD DISEASES

Bacteria and mycoplasmas

Soft rot

Erwinia carotovora pv. *carotovora*

Symptoms

A wet slimy rot of leaves and stalks mainly in transit and storage. In the field, plants often show a soft wet rot of the base and heart.

Source of infection and spread

The bacterium is common in the soil, particularly in decomposing plant matter. It is spread by rain or irrigation water, on implements and by insects.

Infection occurs mainly through injuries such as those caused by Sclerotinia rot and leaf curl. Hot wet weather favours disease development. Plants are often contaminated by bacteria on cutting knives, hands and in wash water. Extensive breakdown occurs if the produce is stored under hot humid conditions.

Importance

Generally minor.

Control

1. Spray with recommended fungicides.
2. Handle plants carefully to avoid injury.
3. Include a recommended bactericide in the wash water.
4. Sterilise knives after cutting infected plants.
5. Store produce under cool, well-ventilated conditions.

Fungicides

Field

Chemicals: copper hydroxide

1. Apply at 10 to 14-day intervals. When cool wet conditions occur, apply every seven days.
2. Use sufficient spray to give good coverage. If using an overhead boom with hollow cone nozzles (one above each row), the volume of spray applied should be as follows:
 - 1 to 4 weeks after transplanting: 400 L/ha
 - 4 to 8 weeks after transplanting: 400 to 800 L/ha
 - 8 weeks to harvest: 800 to 1200 L/ha

Post-harvest treatment (for control of bacterial soft rot)

Add sufficient sodium hypochlorite to the wash water to give a concentration of 100 ppm available chlorine; for example, commercial bleach containing 100 mL of available chlorine/100 L of wash water. As the chlorine dissipates with time, make a fresh solution at least daily.

Fungi

Anthracnose

Colletotrichum orbiculare

Symptoms

Black sunken spots on leaf stalks and leaves. The leaflet stalks are often cinctured causing the leaflets to die. A dark brown rot extends for some distance into the tissues below the spots. Pink spore masses are produced on the spots in wet weather.

Source of infection and spread

The fungus survives on undecomposed celery residues in the soil. Spores are spread rapidly during wet windy weather.

Importance

Rare.

Control

Not generally warranted.

Early blight

Cercospora apii

Symptoms

Leaves: small yellow spots which enlarge rapidly and are irregularly rounded. The colour of the spot changes to orange-grey and the texture becomes dry and papery. In wet weather, a very fine ashen grey fungal mould develops on the spot.

Leaf petioles: elongated spots develop on the petioles.

Source of infection and spread

The fungus survives on undecomposed celery residues in the soil but may also be introduced in the seed. Fungal spores are blown long distances by wind. Heavy persistent dews and wet weather favour the disease.

Importance

May be serious but can be controlled by seed treatment and a regular spray programme.

Control

1. Seed treatment. Treat seed in hot water at 50°C for 30 minutes prior to planting.
2. Spray with recommended fungicides.
3. Destroy old crops promptly.
4. Avoid planting into soil containing infested residues.

Fungicides

Seedbed chemicals: metiram, zineb and ziram.

1. Begin spraying one week after emergence and continue at intervals of seven days until transplanting.
2. Use fungicides at half field strength to reduce the risk of phytotoxicity on seedlings.

Field chemicals: metiram, zineb and ziram.

1. Begin at 7 to 14 days after transplanting and continue at 7 to 14-day intervals to harvest. Use the shorter interval if wet weather occurs.
2. Use sufficient spray to give good coverage. If using an overhead boom with hollow cone nozzles (one above each row), the volume of spray applied should be as follows:
1 to 4 weeks after transplanting: 400 L/ha.
4 to 8 weeks after transplanting: 400 to 800 L/ha.
8 weeks to harvest: 800 to 1200 L/ha.

Leaf curl

Colletotrichum acutatum

Symptoms

Small yellow translucent spots on leaves. Small, cupped and malformed leaves on young plants. Malformation and curling of older leaves. Affected leaf petioles have sunken light brown elongated lesions which may develop and kill the leaf petiole.

Source of infection and spread

The fungus survives on undecomposed celery residues in the soil. Spores are spread rapidly during wet windy weather.

Importance

May be serious but can be controlled by a spray programme.

Control

1. Avoid plant damage when transplanting.
2. Spray with recommended fungicides.
3. Destroy old crops promptly.
4. Avoid planting into soil containing infested residues.

Fungicides

Seedbed.

Chemicals: copper oxychloride, mancozeb, maneb + zineb, zineb and ziram.

1. Begin spraying one week after emergence and continue at intervals of seven days until transplanting.
2. Use fungicides at half field strength to reduce the risk of phytotoxicity on young seedlings.

Field.

Chemicals: copper oxychloride, mancozeb, maneb + zineb, zineb and ziram.

1. Begin at 7 to 14 days after transplanting and continue at 7 to 14-day intervals to harvest. Use the shorter interval if wet weather occurs.
2. Use sufficient spray to give good coverage. If using an overhead boom with hollow cone nozzles (one above each row), the volume of spray applied should be as follows:

1 to 4 weeks after transplanting: 400 L/ha.

4 to 8 weeks after transplanting: 400 to 800 L/ha.

8 weeks to harvest: 800 to 1200 L/ha.

Sclerotinia rot

Sclerotinia sclerotiorum

Symptoms

On leaves and leaf stalks, water-soaked areas rapidly becoming covered with a white cottony fungal growth. In advanced stages, large black irregular resting bodies (sclerotia) form in affected tissues.

Source of infection and spread

The sclerotia produced in affected tissues may survive in the soil for many years. In cool moist weather, those near the surface germinate to produce at the soil surface small cream 'mushroom-like' bodies called apothecia. These contain large numbers of ascospores which are forcibly discharged and carried by wind over long distances. Before the fungus can invade healthy tissues, the spores must first germinate on and infect dead or dying plant material. This is usually present in the form of old leaves which adhere to the leaf stalks in wet weather. The fungus then invades surrounding healthy tissues. The fungus is favoured by cool showery weather, but fogs, mists, dews and irrigation provide enough moisture for infection to occur.

A large number of other crops and weeds are susceptible to Sclerotinia rot.

Importance

Occasionally serious but can be controlled by spraying.

Control

Spray with recommended fungicides.

Fungicides

Chemicals: benomyl, iprodione.

Addition of a wetting agent is recommended.

Generally necessary only in the cooler months in areas where the disease has been a problem previously. Begin spraying 1 to 2 weeks after transplanting and continue at 14 to 21-day intervals.

There is a possibility that resistance to these fungicides may develop. This can be reduced if they are used alternatively in the spray programme.

Septoria spot

Septoria apiicola

Symptoms

On leaves and leaf stalks, small yellowish spots enlarging and turning brown and becoming studded with small black fruiting bodies of the fungus. Affected leaves appear 'fired'.

Source of infection and spread

The fungus survives on undecomposed celery residues in the soil but may be introduced on the seed. Spores produced in the small black fruiting bodies are spread during wet windy weather or overhead irrigation. Cool weather favours infection and disease development.

Importance

May be serious but can be controlled by seed treatment, a regular spray programme and crop rotation.

Control

1. Seed treatment. Treat seed in hot water at 50°C for 30 minutes prior to planting.
2. Spray with recommended fungicides.
3. Use crop rotation to allow celery residues to decompose before replanting to celery.

Fungicides

Seedbed.

Chemical: chlorothalonil.

1. Begin spraying one week after emergence and continue at seven-day intervals until transplanting.
2. Use the fungicides at half field strength to reduce the risk of phytotoxicity on young seedlings.

Field.

Chemicals: chlorothalonil, copper oxychloride and copper hydroxide

1. Begin at 7 to 14 days after transplanting and continue at 7 to 14-day intervals to harvest. Use the shorter interval if wet weather occurs.
2. Chlorothalonil is preferred where conditions are very favourable for the disease.
3. Use sufficient spray to give good coverage. If using an overhead boom with hollow cone nozzles (one above each row), the volume of spray applied should be as follows:
 - 1 to 4 weeks after transplanting: 400 L/ha.
 - 4 to 8 weeks after transplanting: 400 to 800 L/ha.
 - 8 weeks to harvest: 800 to 1200 L/ha.

Crucifers

FIELD DISEASES

Bacteria and mycoplasmas

Black rot

Xanthomonas campestris pv. *campestris*

Symptoms

Yellow V-shaped areas with dark veins around the margin of leaves. Affected areas dry out and turn brown but vein blackening may extend down the leaves into the stem. When the stem is cut across, a black ring will be seen in the water-conducting tissues just beneath the bark.

Most cultivated crucifers are susceptible although some have a useful level of resistance to the disease.

Source of infection and spread

The bacterium is most commonly introduced in seed but may survive on undecomposed crucifer residues and susceptible weeds such as wild radish (*Raphanus raphanistrum*) and shepherd's purse (*Capsella bursa-pastoris*). Infection occurs through the water pores at the leaf margin and insect injuries on the leaf blade. Once established, the bacteria are spread during wet, windy weather or by overhead irrigation. Insects may also spread the organism.

Importance

Major.

Control

1. Use seed that has been treated in hot water.
2. Sow in seedbeds free from undecomposed plant residues.
3. Prevent overcrowding of seedlings.
4. Keep areas bordering seedbeds free from susceptible weeds.
5. Plough-in diseased crops immediately after harvesting. Practice crop rotation and grow two non-cruciferous crops before the next planting of a crucifer.
6. Control weeds and insects.
7. Copper hydroxide sprays will limit the spread of the disease. Commence at first sign of the disease in the field and continue at 7 to 10-day intervals. Do not apply in the heat of the day. Brussels sprouts are copper sensitive.

Cultivars

Cabbages: Eureka, Hybrid 33, Green Coronet and Hi-yield (or Beauty) have some resistance.

Cauliflowers: Hybrid No. 6 and selection 174 are more resistant than Snow Gem and Snowball Y.

Note: When selecting cultivars, factors besides disease reaction need to be considered. Always

consult your local extension officer for further information.

Seed treatment

Hot water seed treatment. Seed should be treated in hot water to control black rot, black leg, bacterial leaf scald and *Alternaria* seedling blight. The temperature and immersion time for the following crucifers are: Cabbage - 50°C for 30 minutes; cauliflower - 50°C for 25 minutes; brussels sprouts - 50°C for 20 minutes; broccoli - 50°C for 20 minutes; radish - 50°C for 30 minutes.

Note:

1. Before hot water treatment, ensure that seed has not already been treated. Carry out a germination test to check seed vigour. Seed of low vigour may have its germination greatly reduced by hot water treatment.
2. Treat seed as close as possible to planting time.
3. Before planting, dust seed with thiram at a rate of 2 to 3 g/kg of seed to prevent seed rot. Remember to screen-off excess dust.
4. Plant into fumigated seedbeds or soil-less potting mix.
5. Some seed containers may indicate that the seed has been 'thiram treated'. This indicates that it has been soaked in warm water at 30°C containing 0.2% active ingredient thiram for 24 hours. This treatment is effective in controlling fungal seed infections but is not effective against bacterial diseases such as black rot. Hot water treatment is still necessary for this seed.

Peppery leaf spot

Pseudomonas syringae pv. *maculicola*

Symptoms

Small purple to black spots on the leaves. Under wet conditions, large areas of leaves may be affected.

Importance

Occurs sporadically but then is often serious.

Control

Generally not warranted.

Zonate leaf spot

Pseudomonas cichorii

Symptoms

On leaves, circular to irregular water-soaked zonate spots, at first light brown in colour but later darkening. As the leaves of the head are pulled away, irregular spotting is evident well into the head.

Source of infection and spread

The bacterium is thought to survive on undecomposed crucifer residues. Rapid spread

occurs during wet windy weather or overhead irrigation.

Importance

Restricted to the cabbage cultivar Greygreen.

Control

Plant recommended cultivars. Greygreen is extremely susceptible and should be avoided on farms where the disease has occurred.

Fungi

Alternaria spot

Alternaria brassicicola

Symptoms

Brownish-black spots up to 10 mm wide on leaves, flower stalks and seed heads. Dark sunken areas may also develop in the curd of cauliflowers. Seedlings may be blighted. Cabbages and cauliflowers are more commonly affected than Brussels sprouts and broccoli.

General

The fungus is widespread but seldom causes serious damage. It may be seed-borne and cause seedling blight but this is generally eliminated by hot water treatment of seed.

Importance

Minor. Most serious in cauliflowers.

Control

Generally not warranted.

Fungicides

Chemicals: mancozeb, copper oxychloride. Addition of a wetting agent is recommended.

1. Begin seven days after transplanting and continue at 14 day intervals until maturity.
2. Do not use copper oxychloride on Brussels sprouts.
3. These sprays are generally not required on cauliflowers or broccoli.
4. These fungicides are compatible with benomyl used for control of Sclerotinia rot. Check the label for directions.

Seed treatment

Refer to black rot for hot water seed treatment details (see p. 23)

Black leg

Leptosphaeria maculans (conidial state: *Phoma lingam*)

Symptoms

Stem: at first, light brown sunken spots near the base of the stem, eventually turning black and girdling it. Small black fruiting bodies of the fungus appear on

the affected area. Internally, the stem shows a brown dry rot.

Leaves: dark round spots with the small black fruiting bodies scattered over the surface.

Source of infection and spread

The fungus is commonly introduced in the seed but may survive on undecomposed crucifer residues. Large numbers of spores produced in the small black, fruiting bodies are spread by rain or irrigation.

Importance

Rare with the widespread use of hot water treated seed.

Control

1. Use seed that has been treated in hot water or a recommended fungicide.
2. Plough-in diseased crops immediately after harvesting and ensure that all residues have thoroughly decomposed before replanting with crucifers.

Seed treatment

Refer to black rot for hot water seed treatment details (see p. 23)

Black root - radish

Aphanomyces raphani

Symptoms

Dark irregular patches on the main root which often coalesce to completely cover the root. Longitudinal cracking of the affected areas may follow but the tissues do not break down unless invaded by secondary organisms.

Source of infection and spread

The fungus is a soil inhabitant and may persist for long periods. It invades the main root where the secondary roots emerge. Warm weather favours the development of the fungus.

Importance

Generally minor but has caused serious losses on some farms.

Control

Improve soil drainage in affected areas.

Club root

Plasmodiophora brassicae

Symptoms

Abnormal enlargement of roots.

Source of infection and spread

The fungus may survive for long periods in the soil and is spread in soil carried by wind, water or machinery.

Importance

The disease is uncommon in Queensland.

Control

Not warranted.

Damping-off

Pythium spp., *Rhizoctonia solani*

Symptoms

Seedlings collapse, wither and die. The disease caused by *Rhizoctonia solani*, particularly in older seedlings, is known as wirestem. Seedlings with wirestem may not die but become stunted with the tissue of the soft outer stem brown and shrunken.

Importance

Minor.

Control

Use seed treated with the recommended fungicide and sow in sterilised seedbeds or soil-less potting mix. If wirestem occurs, drench the affected plants with the recommended fungicide.

Fumigation of seedbed

Treat soil with methyl bromide at a rate of 1 kg/10 m² of seedbed. A standard 680 g can is sufficient to treat 6.8 m² of seedbed. Before treatment, ensure that soil is free from undecomposed organic matter.

Seedbed drench (for control of damping-off caused by *Rhizoctonia solani*). Wirestem is rarely a problem in fumigated seedbeds. If it occurs, apply quintozene (750 g/kg) at a rate of 200 to 300 g/100 m² of seedbed in enough water to drench the soil to a depth of 100 mm. Do not repeat treatment unnecessarily.

Potting mix treatment (for control of damping-off caused by *Pythium* spp.) Thoroughly incorporate metalaxyl (50 g/kg product) at 2.5 g/10 L of potting mix.

Downy mildew

Peronospora parasitica

Symptoms

Leaves: yellow to pale green spots with a white fungal growth on the underside. In moist weather, spots enlarge to form large patches but, with a return to dry weather, these dry out and die. Affected cauliflower heads may show a dark brown discolouration.

Source of infection and spread

The fungus survives on volunteer crucifers including a number of weeds such as shepherd's purse (*Capsella bursa-pastoris*) and hedge mustard (*Sisymbrium officinale*). The mildew produced on the underside of the leaves contains large numbers of spores which are spread by wind and water. Cool moist weather favours rapid development of the fungus. Downy mildew is most serious in the seedbed

where crowded conditions provide ideal conditions for the disease to develop.

Importance

Serious in seedbeds. Minor in the field.

Control

1. Spray with recommended fungicides particularly in the seedbeds.
2. Keep seedbed areas free from susceptible weeds.

Fungicides

Chemicals: mancozeb, metiram, zineb. Addition of a wetting agent is recommended.

1. Begin when the seedlings are about 30 mm high and continue at seven-day intervals until transplanting.
2. Seedlings should be raised in rows to enable better penetration of the spray.
3. Good coverage of the undersurface of leaves is essential.

Seed treatment

For control of downy mildew of radish. Apply metalaxyl (350 g/kg) at the rate of 3.5 g to 1 kg of seed before planting. In wet weather, the downy mildew fungus can infect seedlings before protectant fungicides are usually applied.

Ring spot

Mycosphaerella brassicicola

Symptoms

Leaves: small dark circular spots enlarging up to 20 mm in diameter and becoming light brown to grey towards the centre. Spots may be recognised by the small black fruiting bodies which form on the surface, generally in concentric circles.

In Queensland, ring spot has been recorded on cabbages and cauliflowers.

Source of infection and spread

The fungus survives from season to season on undecomposed crucifer residues in the soil. Spores produced in the small black fruiting bodies are forcibly ejected and carried by wind. Cool wet weather favours infection and disease development.

Importance

Minor in most areas, except the Granite Belt of Queensland.

Control

Plough-in diseased crops immediately after harvesting. Do not replant until all residues have completely decomposed.

Fungicides

Chemicals: mancozeb, metiram, zineb, copper oxychloride. Addition of a wetting agent is recommended.

1. Begin seven days after transplanting and continue at intervals of 14 days until maturity.
2. Do not use copper oxychloride on brussels sprouts.
3. These sprays are generally not required on cauliflowers or broccoli.
4. These fungicides are compatible with benomyl used for control of Sclerotinia rot. Check the label for directions.

Sclerotinia rot

Sclerotinia sclerotiorum

Symptoms

A soft light brown watery rot of leaves and heads with masses of white cottony fungal growth. Small hard black irregularly shaped resting bodies (sclerotia) of the fungus later form in the rotting tissues.

Most cultivated crucifers are susceptible.

Source of infection and spread

The sclerotia formed in affected tissues enable the fungus to survive for many years in the soil. Those near the surface germinate in moist weather to produce at the soil surface small cream 'mushroom-like', fruiting bodies (apothecia) containing large numbers of spores (ascospores). These are forcibly ejected and may be carried by wind over many miles. However, the fungus cannot infect healthy tissues directly and first colonises dying or injured tissues. Sclerotinia rot is favoured by cool showery weather but fogs, mists, dews and irrigation provide enough moisture for infection to occur. The fungus attacks many crop plants and weeds.

Importance

Generally minor.

Control

Spray with recommended fungicides.

Fungicides

Chemicals: benomyl or vinclozolin plus wetting agent as recommended by the manufacturer.

1. Begin when the disease is first seen and continue at 10 to 14-day intervals as required.
2. Should be necessary only in infested areas in the cool months or when prolonged wet weather occurs.

Yellows

Fusarium oxysporum f.sp. *conglutinans*

Symptoms

Affected plants lose vigour and the lower leaves yellow. In half-grown plants, leaves tend to be bent sideways with one side retarded in growth and pale yellow in colour. Symptoms may show on one side of the plant only.

If the stem is cut across near ground level, a brown discolouration of the water-conducting tissues just beneath the bark is seen. The one-sided

development of leaves results from this browning being more advanced on one side of the stem. In Queensland, yellows has been recorded on cabbages and cauliflowers.

Source of infection and spread

The fungus may survive for long periods in the soil. It affects the plant through the roots and grows into the water-conducting tissues. Warm weather favours the development of the disease. The fungus is spread in soil adhering to implements and the shoes of workers and by transplanting seedlings grown in infested soil.

Importance

Minor.

Control

Plant recommended cultivars.

Cultivars

The cabbage cultivars Eureka, Olympic, Selection 316, YR Summer 50, Selection 211A, Selection 1488, Rambo and All Seasons are resistant. Cauliflowers rarely contract the disease.

Note: When selecting cultivars, factors besides disease reaction need to be considered. Always consult your local extension officer for further information.

White blister

Albugo candida

Symptoms

Small circular raised yellowish-green spots on the upper surface of leaves with masses of white powdery spores in corresponding positions on the lower surface. Severely affected leaves are malformed, wilt and die.

The disease is serious only on radish. Turnips are also affected.

Source of infection and spread

The fungus survives on undecomposed radish residues and on a number of common cruciferous weeds including wild radish (*Raphanus raphanistrum*), turnip weed (*Rapistrum rugosum*), shepherd's purse (*Capsella bursa-pastoris*), bitter cress (*Coronopus didymus*) and hedge mustard (*Sisymbrium officinale*).

Spores produced on the underside of leaves are spread by wind and rain. Cool wet weather favours infection and disease development.

Importance

Rare.

Control

1. Keep area around crop free from susceptible weeds.
2. Ensure that all radish residues are thoroughly decomposed before sowing.

Viruses

Black ringspot

Turnip mosaic virus

Symptoms

During warm weather, only a mild leaf mottle is present but under cold conditions characteristic dark rings and bands are formed, enclosing areas of normal green tissue.

Source of infection and spread

The main sources of infection are other diseased cruciferous crops and weeds.

The virus is spread by several species of aphids and is acquired and transmitted during short feeding probes.

Not all strains of turnip mosaic virus affect cabbage. The disease is not common in Queensland, partly because of the cold temperature requirement for expression of severe symptoms.

Importance

Rare.

Control

1. Control cruciferous weeds around the crop area.
2. Avoid growing cabbages in very cold weather if the disease has been prevalent.
3. Use less susceptible cultivars.

POST-HARVEST

Bacteria and mycoplasma

Soft rot

Erwinia carotovora pv. *carotovora*

Symptoms

A soft mushy decay of the heads with a very offensive odour. Bacterial slime is often seen on affected areas.

All cultivated crucifers are susceptible.

Source of infection and spread

The bacteria are commonly associated with decaying vegetable matter in the soil. They invade only tissue which has been damaged and often follow other diseases. Hot weather favours the development of the rot, which may be particularly severe if the crop is harvested when wet. In the field, spread occurs by water splash and on cutting knives; while in transit and storage, it occurs by contact and by bacterial ooze dripping from diseased leaves. Although the disease is mainly a post-harvest problem, cabbages in the field will sometimes show a soft rot of the stem penetrating up into the base of the head. These heads are unmarketable but, if cut, the knife becomes contaminated and serves to spread the bacteria to subsequent heads.

Importance

Can be serious in hot weather.

Control

1. Avoid harvesting when the crop is wet.
2. Handle produce carefully and store in a cool, well-ventilated area.
3. Do not cut diseased heads. If one is cut inadvertently, wash knife thoroughly in methylated spirit
4. Plough-in crops immediately after harvesting so that residues decompose as quickly as possible.

Post-harvest treatment of brussels sprouts (where bacterial soft rot has been a serious problem).

Dip sprouts immediately after harvest in a sodium hypochlorite solution containing 50 ppm available chlorine; for example, 160 mL of a commercial bleach containing 3.5% sodium hypochlorite per 100 L of water. Addition of a wetting agent is recommended. After dipping, allow sprouts to thoroughly dry before packing. As the chlorine dissipates with time, make a fresh solution at least daily or check the chlorine concentration regularly with a swimming-pool test kit and maintain at the recommended level. Where available, cool storage is also recommended.

Cucurbits

FIELD DISEASES

Bacteria and mycoplasmas

Angular leaf spot

Pseudomonas syringae pv. *lachrymans*

Symptoms

Leaves: irregular or angular spots at first water-soaked but later drying out to produce a pale spot which may be encrusted with a thin film of dried bacterial ooze. Individual spots may tear giving the leaf a ragged appearance.

Fruit: small circular water-soaked spots drying to almost white and often cracking.

Source of infection and spread

The bacterium is seed-borne and may also survive from season to season on undecomposed crop residues. Spread of the disease is favoured by wet weather.

Importance

Rare.

Control

Generally not warranted.

Bacterial spot

Xanthomonas campestris pv. *cucurbitae*

Symptoms

Leaves: small tannish-yellow angular spots, 1 to 2 mm wide. Under wet conditions, they appear greasy on the undersides. If a number of spots occur together, that section of the leaf may brown and die.

Fruit: on young immature fruit, small water-soaked areas with a pronounced light brown ooze. As the fruit enlarge, the ooze dries to form a raised yellow crust over the spot.

On mature fruit, spots may be up to 10 mm wide with a dark green greasy margin. Young fruit are more susceptible being relatively soft and lacking the resistant wax layer which develops on the surface of older fruit. Affected fruit are unmarketable and secondary rots often cause complete loss.

The flesh beneath spots may be dark and water-soaked extending into the seed cavity. As a result, seed becomes contaminated.

Source of infection and spread

The disease is commonly introduced in seed. Once established, it spreads rapidly in wet windy weather and during overhead irrigation. Cool damp weather favours disease development.

The bacterium may survive on undecomposed crop residues.

Importance

Has often been a cause of severe loss in pumpkins. Occurs less frequently in rockmelon.

Control

1. Select seed from disease-free fruit and apply the recommended seed treatment.
2. Plough-in diseased crops immediately after harvesting.

Treatment of pumpkin seed (for control of bacterial spot in areas where the disease is a problem).

Soak seed for 40 minutes in a solution made up of 5 parts commercial hydrochloric acid (31.5% w/w), 1 part wetting agent and 94 parts water. This rate applies only to commercial hydrochloric acid of 31.5% w/w and with a specific gravity of 1.16. If other concentrations are used, rate will have to be adjusted accordingly. While seed is soaking, stir intermittently to ensure thorough wetting. After treatment wash seed thoroughly with running water.

Note:

1. Use only heavy plastic or glass containers for treating seed. **Do not use metal containers.**
2. **Concentrated hydrochloric acid is a highly dangerous chemical and should be handled with extreme care. Always wear protective clothing.**
3. Acid treatment also controls seed-borne *Fusarium* foot rot.
4. Seed of other cucurbits, for example, rockmelon may be damaged by this treatment.

Fruit blotch - watermelon

Pseudomonas sp.

Symptoms

On fruit, water-soaked, circular to oval-shaped areas on the skin, generally on the upper half. The rind beneath these areas generally remains unaffected but may sometimes dry out and become slightly discoloured.

Source of infection and spread

Unknown. The disease is restricted in its occurrence.

Importance

Rare.

Control

None available.

Rind breakdown

Pseudomonas pseudoalcaligines sub. sp. *citrulli*

Symptoms

Has only been found on watermelon. Occurs as a small brown spot on the underside of fruit. The lesion extends through the skin and into the rind.

Importance

Rare.

Control

Generally not warranted.

Fungi**Alternaria leaf spot**

Alternaria cucumerina

Symptoms

On leaves, small tan-coloured spots enlarging to roughly circular, brown areas sometimes with concentric ring markings. Spots may coalesce to cover almost the whole leaf.

Source of infection and spread

The fungus survives on undecomposed cucurbit residues in the soil but may also be introduced on the seed. Spores are spread by wind and rain.

Importance

Affects the majority of cucurbits but is more common on pumpkin and cucumber. Generally of minor importance.

Control

Spray with the recommended fungicide (mancozeb).

Anthracnose

Colletotrichum orbiculare

Symptoms

Leaves: small brown circular areas with a yellowish halo. These enlarge to form circular to elongated dark brown to black spots, often centred on the veins.

Runners: pale brown, slightly sunken elongated areas.

Fruit: circular pale brown depressed spots with a raised margin, usually concentrated on the lower half of the fruit. Spots generally are up to 30 mm wide but often coalesce to cover large areas of the fruit. Pink to orange spore masses are produced on the spots in moist weather. Although the infection does not reach the flesh, secondary rots may develop, causing extensive decay.

Source of infection and spread

The fungus survives on undecomposed crop residues and may be carried on the seed. The orange to pink spores produced on affected parts are spread by splashing water.

Importance

The disease can be serious on watermelon. Leaf symptoms also occur on rockmelon and cucumber.

Control

1. Use the recommended seed treatment.

2. Spray with recommended fungicides.

Fungicides

Chemicals: propineb, zineb, metalaxyl + mancozeb.

1. Spray at 7 to 14-day intervals, beginning when the plants start to run. Use the shorter interval if prolonged wet weather occurs.
2. Good spray coverage is essential.
3. This spray may generally be mixed and applied with the spray required for powdery mildew. Check individual labels for details.
4. Propineb and metalaxyl plus mancozeb should be applied only to watermelon.

Seed treatment (for control of anthracnose, damping-off and gummy stem blight)

Dry seed. Treat seed with a slurry containing 100 g benomyl (500 g/kg)/200 mL water. Mix the seed thoroughly with the slurry, drain off excess liquid and dry before planting.

Pre-germinated seed. Dip seed for 30 seconds just prior to planting in a suspension of 5 g benomyl (500 g/kg) in 1 L of water. Do not exceed this rate as damage to the seed may occur.

Brown etch of grammas - Butternut

Fusarium oxysporum, *Fusarium roseum* and *Ascochyta cucumis*

Symptoms

Bronze-coloured areas with concentric bands on the fruit, mostly on the lower surface. These areas may be quite large and often crack in the centre. Only the skin of the fruit is affected but, if secondary rots enter through the cracks, complete breakdown may occur.

Source of infection and spread

The fungi causing brown etch are soil inhabitants and first invade that portion of the fruit in contact with the soil. The disease is favoured by warm wet weather. Symptom development ceases once the fruit is mature.

Importance

Serious in Butternut grammas.

Control

Use other cultivars in badly infested areas and during the summer.

Damping off

Pythium spp., *Rhizoctonia solani*

Symptoms

A collapse and death of seedlings before or after emergence. A wet rot of the stem at or below ground level is common.

Importance

Serious in the cooler months where untreated seed is used, particularly in cucumbers and pumpkins.

Control

1. Treat seed with the recommended fungicide before planting.
2. Plant first on the warmer northern slopes.

Seed treatment (for control of anthracnose, damping-off and gummy stem blight)

As for Anthracnose (see p. 30).

Downy mildew

Pseudoperonospora cubensis

Symptoms

On leaves, small pale yellow areas which enlarge and dry out to form brown angular spots, often delineated by the veins. In humid weather, a purplish downy growth may be seen on the undersides of spots. Affected leaves curl, shrivel and die.

Source of infection and spread

In moist weather, the purplish growth produces large numbers of spores. These are spread by wind to new leaves where infection occurs provided water is present. Warm moist weather favours disease development.

Importance

The majority of cucurbits are affected with the disease being particularly severe in susceptible cultivars of cucumber, rockmelon and zucchini. The disease is difficult to control in wet weather.

Control

1. Spray with recommended fungicides.
2. Use resistant cultivars.

Fungicides

Chemicals: mancozeb, metiram, propineb, zineb, metalaxyl + mancozeb.

1. Spray at 7 to 14-day intervals, beginning when the plants start to run. Use the shorter interval if prolonged wet weather occurs.
2. Good spray coverage is essential.
3. This spray may generally be mixed and applied with the spray required for powdery mildew. Check individual labels for details.
4. Some cultivars are resistant to downy mildew but may still have to be sprayed to control anthracnose and gummy stem blight.
5. Metiram should be applied only to cucumbers.
6. Propineb should be applied only to cucumbers and rockmelons.

Fusarium wilt

Fusarium oxysporum

Note on cause

The fungi *Fusarium oxysporum* f. sp. *niveum* (watermelons), *Fusarium oxysporum* f. sp. *melonis* (rockmelons) and *Fusarium oxysporum* f. sp. *cucumerinum* (cucumbers) are specific to their respective host crops.

Symptoms

In seedlings, the cotyledons or seed leaves lose their healthy lustre and wilt, followed by the complete collapse of the plant. Older plants first show a wilting and yellowing of leaves near the crown. Later, individual runners and then the whole plant become affected. Some recovery may occur at night but the plant finally dies. If the tap-root and stem are split open, an orange-brown discolouration of the water-conducting tissues is seen. Fruit from affected vines are small with poor flavour and colour.

Source of infection and spread

The fungus is a soil inhabitant entering the plant through the root and growing into the water-conducting tissues. It may also be carried on the seed and in soil adhering to implements. The disease is favoured by warm weather and the fungus persists for long periods in the soil.

Importance

Serious in some areas, particularly in watermelons.

Control

Use resistant cultivars.

Cultivars

Watermelons: Calhoun Grey is resistant and Warpaint moderately resistant to the most common race of the *Fusarium* wilt fungus. However, they are susceptible to a new race of the fungus now present in central and north Queensland. Candy Red, All Sweet, Charleston Grey and Sunnyboy are susceptible to both races of the fungus.

Gummy stem blight

Didymella bryoniae

Symptoms

Leaves: more or less circular brown spots up to 20 mm wide. If located on a midrib, these may be larger and irregular. Spots may tear and drop out, giving the leaves a tattered appearance.

Crown and runners: at first pale brown, then bleached areas develop, with a reddish gum oozing from cracks. Affected areas are studded with small, black dots which are the fruiting bodies of the fungus. Runners may be girdled and die.

Fruit: black leathery sunken spots with a firm texture occasionally occur.

Source of infection and spread

The fungus survives on undecomposed crop residues and rarely may be introduced with the seed. The small black fruiting bodies contain large numbers of spores which are spread by wind and splashing water.

Importance

Widespread and serious in watermelons and rockmelons.

Control

1. Use the recommended seed treatment.
2. Spray with recommended fungicides.

Fungicides

Chemicals: metiram, propineb, metalaxyl + mancozeb.

1. Spray at 7 to 14-day intervals, beginning when the plants start to run. Use the shorter interval if prolonged wet weather occurs.
2. Good spray coverage is essential.
3. This spray may generally be mixed and applied with the spray required for powdery mildew. Check individual labels for exact details.
4. Propineb should be applied only to watermelon and metiram only to cucumbers.

Seed treatment (for control of anthracnose, damping-off and gummy stem blight)

As for Anthracnose (see p. 30).

Powdery mildew

Sphaerotheca fuliginea

Symptoms

Small, more or less circular, white powdery patches on leaves, runners and leaf stalks. These are generally first observed on the undersides of leaves but eventually cover both surfaces. Affected leaves shrivel and die which may lead to sunburn of exposed fruit.

Source of infection and spread

The white mildew consists of large numbers of spores which are spread by wind. Unlike downy mildew, this disease flourishes in comparatively dry weather, germination of spores being inhibited by free water on the leaf surface. Dews provide sufficient moisture for infection to occur. Late crops are generally most severely affected.

Importance

Serious in susceptible cultivars but can be controlled by fungicides.

Control

1. Spray with recommended fungicides
2. Use resistant cultivars. Since races 1 and 2 of *Sphaerotheca fuliginea* are widespread, resistant cultivars will need to be resistant to both races of the fungus.

Fungicides

Chemicals: dimethirimol, dinocap, fenarimol, oxythioquinox, pyrazophos, wettable sulphur, sulphur dust (pumpkins only), triadimefon.

1. Fungicide resistance may develop to the highly active systemic fungicides. This is less likely to occur if they are used strategically in a programme with contact fungicides.
- (a) Spray with oxythioquinox at 7 to 10-day intervals from planting until early fruit set.

- (b) After fruit set alternate or tank mix oxythioquinox and a registered systemic fungicide at 7 to 10-day intervals.
2. Sulphur may damage cucumbers and rockmelons and should not be used on these crops. It may also cause leaf scorch on other cucurbits if applied at temperatures above 24°C.
3. Sulphur dust will have to be reapplied after rain or irrigation.
4. Do not apply dimethirimol as a low volume high concentrate spray as leaf scorch may result. Use in the volumes of water indicated on the label.
5. Do not apply dinocap when temperatures exceed 28°C.
6. The manufacturers of some products recommend the addition of wetting agents. Check individual labels for details.

Rhizoctonia ground rot

Rhizoctonia solani

Symptoms

On the under-side of fruit, small circular water-soaked spots enlarging to tan or light brown sunken areas sometimes with surface cracking.

Importance

Watermelon, rockmelon and cucumber are affected. Generally of minor importance.

Control

As for Sclerotium ground rot (see p. 33).

Sclerotium ground rot

Sclerotium rolfsii

Symptoms

On the under-side of fruit, small light brown areas surrounding wounds. These areas become soft and watery and crack open. A white fungal growth in which small brown spherical resting bodies form may cover affected areas. The base of the stem may be similarly affected causing the vine to wilt.

Source of infection and spread

The fungi are common soil inhabitants associated with decaying material. Hot wet weather favours their development. Extensive fruit breakdown may occur during transit and storage.

Importance

Affects watermelon and rockmelon. Generally of minor importance.

Control

1. Prepare land early so that crop residues in the soil have thoroughly decomposed before planting.
2. Do not market fruit showing signs of ground rots.

Septoria spot

Septoria cucurbitacearum

Symptoms

Leaves: small brown spots with the centres eventually drying out and becoming studded with small black fruiting bodies of the fungus.

Fruit: small, circular, light brown, raised scabs with star-shaped cracks.

Source of infection and spread

The fungus survives on undecomposed pumpkin residues. Large numbers of spores produced in the small black fruiting bodies are spread by rain. Cool weather favours infection and disease development.

Importance

Although occasionally found on marrow and squash, Septoria spot is mainly a disease of pumpkin. The disease is not common.

Control

Spray with recommended fungicides.

Fungicides

Chemicals: mancozeb, metalaxyl + mancozeb.

1. Spray at 7 to 14-day intervals, beginning when the plants start to run. Use the shorter interval if prolonged wet weather occurs.
2. Good spray coverage is essential.
3. This spray may generally be mixed and applied with the spray required for powdery mildew. Check individual labels for exact details.

Nematodes

Root-knot nematodes

Meloidogyne spp.

Symptoms

Galls or swelling on roots. All cucurbits may be affected.

Importance

Serious in some crops.

Control

Treat the soil with a recommended nematicide before planting.

Preplant fumigation (for control of nematodes when planting infested areas)

Use **one** of the following soil treatments:

- (a) Treat soil with EDB. Apply as a row treatment using 2 drills 300 mm apart and roll after treatment. Apply at recommended label rates to achieve 110 kg of EDB/ha.

Note:

Apply at least 10 days before planting.

- (b) Apply fenamiphos spray at the rate of 24 L in 150 to 300 L of water/ha, one to seven days before planting. Use a boom spray at 150 to 200 kPa as

an overall treatment. Apply while the soil is moist after rain or irrigation and immediately incorporate to 100 mm with a rotary hoe or discs. Read labels carefully. Alternatively, apply on a 60 cm band at 16 mL/140 to 280 mL of water/10 m and incorporate to 100 mm. **This chemical is extremely dangerous. Follow safety directions on label.**

Viruses

Mosaic

Watermelon mosaic virus

Note on cause

Two types of watermelon mosaic virus (WMV) occur in Queensland. Watermelon mosaic virus type 1, (also known as papaya ringspot virus, cucurbit strain (PRSV-W)), severely affects watermelons and causes distortion of fruit in other cucurbits. WMV-type 2 occurs rarely in watermelons and causes only mild distortion of squash and marrow fruit. Zucchini yellow mosaic virus (ZYMV) is now also present in most cucurbit-growing areas of Queensland. It affects all commercial types of cucurbits and causes severe fruit distortion of pumpkins, zucchinis and button squash.

Symptoms

Infection by WMV-type 1 causes a prominent light and dark green mosaic pattern on leaves. Terminalis of recently affected watermelons tend to stand more erect, with the mosaic pattern developing later. Affected zucchinis show severe lumpy distortion of fruit and leaves may become fern-like. Fruit of pumpkins often develop wart-like lumps.

Zucchini yellow mosaic virus produces a more yellow mosaic on leaves as well as fruit distortion. The first few leaves affected on rockmelons may progress from chlorosis to full necrosis.

Source of infection and spread

The main sources of infection are old diseased cucurbit crops, home garden plants and weed species such as wild gherkin (*Cucumis anguria*). The virus is spread by many species of aphids including a large green aphid, *Macrosiphum euphorbiae*, and a smaller, olive-green or black aphid, *Aphis gossypii*. Winged aphids may be carried several kilometres by wind. The virus may be acquired and transmitted by aphids probing leaves for only half a minute but it is generally spread only to the first plant an aphid feeds on after being acquired.

Losses in watermelons and pumpkins are greatest if infection occurs during the main fruit-setting period.

Importance

WMV-type 1 is a major cause of loss in pumpkin, squash, watermelon and zucchini. Zucchini yellow mosaic virus causes severe yield losses in pumpkin, zucchini and button squash. Papaw and butternut

pumpkins do not show as much fruit distortion. Cucumbers are usually less severely affected by virus disease.

Control

1. Plough-in old cucurbit crops as soon as harvesting is completed.
2. Avoid overlapping crops of cucurbits, particularly zucchinis.
3. Use resistant cultivars, if available.
4. Reflective plastic mulch can delay disease development in zucchini and in other cucurbit species which do not rapidly cover the mulched area. This treatment may be used in conjunction with weekly applications of a mineral oil/insecticide mix which is applied to thoroughly cover the leaf surfaces.

POST-HARVEST

Bacteria and mycoplasmas

Soft rot

Erwinia carotovora pv. *carotovora*

Symptoms

Rockmelons are particularly susceptible.

The disease occurs after harvest and generally begins at the stem-end. Since the flesh is rotted in preference to the skin, the fruit is often left as a hollow shell containing unpleasant smelling liquid. The disease is easily confused with, and often occurs with *Geotrichum* soft rot.

Source of infection and spread

Bacterial soft rot is serious only in warm wet weather. Bacteria present in the soil enter the fruit through small cracks in the stem-end under wet conditions. Contaminated washing water spreads the disease from fruit to fruit. Post-harvest dips used for fungal diseases do not control bacterial soft rot.

Importance

Major in rockmelons.

Control

Refer to control measures for *Rhizopus* soft rot (see p. 35).

Fungi

Cottony leak

Pythium aphanidermatum

Symptoms

On cucumber and zucchini fruit, soft dark green water-soaked spots occur which develop into a watery soft rot. The rot is eventually covered by a

white cottony mould. As the rot penetrates well into the fruit, water is liberated in quantity.

Source of infection and spread

The fungus is a soil-inhabiting water mould which is active during wet weather or in poorly drained soils. Although initial infection occurs in the field, spread is most rapid in transit or storage, particularly where fruit have been packed wet and then stored in a humid environment. The fungus spreads from fruit to fruit by contact.

Importance

Occasional market consignments are seriously affected.

Control

1. Avoid harvesting during wet weather.
2. Do not pack fruit showing evidence of decay.

Fusarium fruit rot

Fusarium spp.

Symptoms

Small scattered inconspicuous spots on the skin, becoming distinctive as white to pinkish fungal growth develops and spreads over large areas of the fruit.

Source of infection and spread

The fungi are common soil inhabitants and generally infect the fruit on the underside. However, spores may be splashed onto any part of the fruit during rain or irrigation. Hot wet weather, particularly at harvesting, favours rapid development of the rot. Extensive breakdown may occur during transit and storage if affected fruit are packed.

Importance

Major.

Control

1. Avoid harvesting during wet weather.
2. Store fruit in a cool, well-ventilated place.
3. Do not pack fruit showing signs of rot.
4. Refer to control measures for *Rhizopus* soft rot.

Geotrichum fruit rot

Geotrichum candidum

Symptoms

Rockmelons are particularly susceptible.

The disease occurs after harvest and begins at the stem-end. The flesh is rotted in preference to the skin. The fruit is left as a hollow shell containing an unpleasant smelling liquid. A white cheesy fungal growth is often visible on decayed tissue. The disease is often confused with and may occur with bacterial soft rot.

Source of infection and spread

Geotrichum soft rot is a common cause of wastage in rockmelons. The fungus frequently originates in the soil and enters the fruit through small cracks in the stem-end under wet conditions and spreads from fruit to fruit in contaminated wash water. Vinegar flies may also transmit the fungus.

Importance

Major in rockmelons.

Control

Refer to control measures for Rhizopus soft rot.

Rhizopus soft rot

Rhizopus stolonifer

Symptoms

Rhizopus soft rot is a post-harvest disease affecting rockmelons in particular. Fruit may be attacked at any point but entry through the stem end is most common. Unlike bacterial soft rot and Geotrichum soft rot, Rhizopus soft rot advances through the entire fruit on an even front. Black fungal 'whiskers' are visible in advanced cases.

Source of infection and spread

Spores of the fungus are air-borne and are produced in black heads on the whiskery fungal growth on diseased fruit. Spread occurs after harvest and fruit becomes infected from spores which land on the stem-end or on wounds.

Importance

Can be serious.

Control

Post-harvest hygiene and care in handling fruit are particularly important. The following control recommendations contains an integrated programme for control of Rhizopus soft rot, Fusarium rot, Geotrichum soft rot and bacterial soft rot of rockmelons. Rhizopus soft rot and bacterial soft rot may affect other cucurbits to a lesser extent and may require some of the control measures.

Post-harvest control of rots in cucurbits

1. Avoid, where possible, harvesting in wet weather. The incidence of Geotrichum and bacterial soft rots will be less if harvesting is carried out in the coolest part of the day.
2. Handle fruit carefully.
3. If fruit must be washed, do so in clean non-recirculated water. This is particularly important when bacterial soft rot is present.
4. Cool fruit rapidly and as soon as possible after harvest. Recommended storage conditions for rockmelons are 2°C at 85% RH for up to 14 days. Development of bacterial soft rot in particular is restricted at temperatures below 10°C. If refrigeration is not available, the fruit should be stored in a cool well-ventilated area.
5. Remove diseased fruit from in and around the packing shed, particularly when Rhizopus soft rot is a problem.
6. On rockmelons, use the recommended post-harvest fungicidal treatment for Fusarium rot, Geotrichum soft rot and Rhizopus soft rot.

Post-harvest fungicidal treatment of rockmelons (for control of post-harvest rots)

As soon as practicable after harvesting, dip fruit for one minute in the following mixture: 100 g benomyl (500 g/kg) plus 10 mL Nonidet WK® or Agral® 60 wetting agent plus 125 mL guazatine (400 g/kg) per 100 L of water. Allow the fruit to dry before packing.

Note: it is essential that the ingredients of the mixture be mixed in the following order:

Mix the benomyl with a little water to form a smooth paste and stir into the full volume of the dip. Add the wetting agent and stir. Then stir in the guazatine.

The wetting agent must be added before guazatine because benomyl and guazatine are compatible only in the presence of the wetting agent.

Although the dip is effective when used at shed temperature, it is more effective when heated. Dip temperatures up to 55°C have been used experimentally without adverse effects on fruit. Mango hot water dipping tanks should be effective but growers wishing to use heated dips should test the suitability of their equipment by treating a small quantity of fruit and observing it over a period of 7 to 10 days.

Ginger

FIELD DISEASES

Bacteria and mycoplasmas

Bacterial wilt

Pseudomonas solanacearum

Note on cause

The bacterium *Pseudomonas solanacearum* biotypes III and IV. Biotype III causes a slow wilt of little significance while biotype IV causes rapid wilting and death.

Symptoms

Plants: wilting and yellowing of the lower leaves, extending upwards until all leaves are affected. The stem becomes water-soaked and readily breaks away from the rhizome. Water-conducting tissues in the stem darken.

Rhizomes: affected rhizomes are generally darker than normal and have water-soaked areas with pockets of milky fluid between them. When rhizomes are cut and a little pressure applied, a milky exudate appears.

Source of infection and spread

The bacterium survives in the soil and on a wide range of crop plants and weeds including tomatoes, potatoes, capsicums, egg plants, blackberry nightshade (*Solanum nigrum*), thickhead (*Crassocephalum crepidioides*), cape gooseberry (*Physalis peruviana*), wild gooseberry (*Physalis minima*) and wild tobacco tree (*Solanum mauritianum*). The bacterium may be introduced in seed pieces. It is spread by irrigation, rain and flood water and in soil adhering to farm machinery and animals.

Importance

Rare, but a devastating disease when it occurs.

Control

1. Plant only disease-free seedpieces.
2. Avoid rotation with susceptible crops and keep weeds under control.
3. Destroy crop residues immediately after harvesting and disinfect machinery, particularly before proceeding to other farms.
4. Affected areas must be fenced to prevent spread by animals, and plant them with a recommended cover crop.

Disinfection of machinery before moving from one farm to another (to prevent spread of bacterial wilt)

1. Remove all soil and plant debris adhering to implements by thorough hosing.
2. Disinfect by prolonged steam cleaning or by spraying with a 12% solution of commercial

formalin. The formalin must remain in contact with the implement for at least one minute. Because formalin is corrosive, wash well with water immediately afterwards. **Caution:** This is a potent product which is unpleasant to use and should not be inhaled. In confined spaces, wear a full face mask with the correct canister. Wear protective clothing.

Big bud

Mycoplasma-like organism

Symptoms

Affected plants cease to grow and leaves become bunched at the top of the stem. In advanced stages of the disease, plants yellow and die.

Source of infection and spread

A large number of crop plants and weeds are susceptible and provide a source of infection. It is spread by a leafhopper.

Importance

Occurs sporadically but is generally of minor importance.

Control

Generally not warranted except in 'seed' production areas where affected plants should be removed when detected.

Fungi

Armillaria rot

Armillaria luteobubalina

Symptoms

Plants yellow and wilt. Rhizomes of affected plants have black string-like threads known as 'shoestrings' adhering to them.

General

The fungus is a common parasite of forest trees and the disease is seen only in ginger planted in recently cleared forest country.

Importance

Rare.

Control

Remove roots and stumps of trees and grow several annual crops if possible before planting new areas to ginger.

Fusarium seedpiece rot*Fusarium oxysporum* f.sp. *zingiberi***Symptoms**

Leaves: stunting and yellowing, then a drying out of the lower leaves and eventually the whole plant.

Rhizomes: a brown internal discolouration accompanied by shrivelling. In the final stages of decay, all that remains of the rhizome is the shell containing fibrous tissue. A white cottony fungal growth may develop on the surface of stored rhizomes.

Source of infection and spread

The fungus is commonly introduced on seedpieces. Once introduced into soil, it may survive for many years. Infection of plants occurs through the roots or cracks and injuries to the skin. Pre-emergent rotting of unprotected seedpieces may occur.

Importance

Major, particularly in late harvest crops.

Control

1. Plant only disease-free seedpieces. During cutting, reject all rhizomes showing internal discolouration.
2. Dip seed pieces in the recommended fungicide as soon as they are cut.
3. Avoid damaging seed pieces during bagging or planting.

Seedpiece dip (for control of *Fusarium* rhizome rot). As soon as practicable after preparation, dip seedpieces for one minute in a suspension of benomyl or carbendazim at recommended label rates. Add a wetting agent as recommended by the manufacturer. After dipping, allow seedpieces to drain thoroughly.

Note:

1. Agitate the mixture while dipping.
2. Top-up the dip when necessary with a suspension of the same strength as the original dip.

Pythium seedpiece rot*Pythium* sp.**Symptoms**

A brown internal discolouration of rhizomes followed by a soft wet rot. A white fungal growth may also be present. Rhizomes become hollowed out.

General

The disease is generally a problem only where rhizomes are harvested or cut when wet or stored under moist conditions. It is most common in ginger harvested from poorly drained areas.

Importance

Serious in wet seasons.

Control

1. Avoid harvesting or cutting rhizomes when wet.

2. Dry seedpieces thoroughly after dipping.

3. Stack bags so that air can circulate freely around them.

Rhizome/basal stem rot*White sterile fungus (Pterula sp.)***Symptoms**

Plants: a yellowing and drying out of stems and leaves. When plants are pulled, the stems invariable break from the rhizome.

Rhizomes: sunken spots beneath the scale leaves are the first symptom. Later, a dark brown rot of the rhizome occurs and roots may be killed. In severe cases, the base of the stem may be hollowed out and filled with a white fungal growth. This growth sometimes envelops the rhizome.

Source of infection and spread

The fungus survives in the soil on undecomposed plant residues from which it sends out white strands through the soil. The most serious outbreaks of this disease have occurred after sugar-cane growing where a large quantity of trash has remained in the soil.

Importance

Prevalent but rarely serious.

Control

Prepare land early to allow plant residues ample time to decompose.

Sclerotium rhizome rot*Sclerotium rolfsii***Symptoms**

White cottony threads on the rhizome and stem. Later, small brown spherical resting bodies (sclerotia) form on affected areas.

Importance

Minor.

Control

Generally not warranted.

Nematodes**Root-knot nematode***Meloidogyne javanica***Symptoms**

Affected plants are stunted and have yellow leaves with marginal browning and swollen distorted roots. Rhizomes show brown water-soaked areas in the outer tissues, particularly in the angles between shoots. Rhizomes held over for planting in the following season may show extensive breakdown in storage.

Source of infection and spread

Root-knot nematodes are widespread, occurring in virgin soils, and have many alternative hosts. They are commonly spread in seed-pieces.

Importance

Major, particularly in late harvest crops.

Control

1. Plant only nematode-free seed pieces.
2. Fumigate soil with a recommended nematicide before planting.

Production of nematode-free planting material

1. Select an area where ginger was not grown in the previous season and with no history of severe nematode infestation.
2. Begin land preparation in late autumn so that the soil is suitable for fumigation by August. Fumigate with ethylene dibromide (EDB) at a rate which will achieve 100 kg EDB/ha. Apply at a depth of 200 mm in rows 300 mm apart. Allow at least two weeks between fumigation and planting.
3. Select planting material as free from nematodes as possible and treat in hot water at 48°C for 20 minutes. Cool the rhizomes before cutting and dipping in benomyl or carbendazim. Seed should be planted within one week of hot water treatment. The hot water tank used for the treatment of banana planting material is suitable for treating ginger.
4. Grow under a sawdust mulch. If this is not available, sprinkle granules of fenamiphos (100 g/kg) over the soil between the plants at 110 kg/ha in mid-November and mid-January. Irrigate after application. Hold the rhizomes from the crop for planting in the following season.

Fumigation of areas for processing crops (for control of nematodes)

Treat the soil with EDB two or more weeks before planting. Apply one of the various formulations of EDB at rates which will achieve 110 kg EDB/ha. Use planting material produced as

above or if unavailable, obtained from an area with no more than a light infestation of nematodes. When cutting, discard any rhizomes showing symptoms of nematode infestation.

Note: Do not grow cowpeas, field peas or tomatoes in rotation with ginger. Land to be left idle for 12 months or longer can be sown with green panic (6 kg/ha). Slash before the grass seeds.

POST-HARVEST

Bacteria and mycoplasmas

Soft rot

Erwinia carotovora pv. *carotovora*

Symptoms

A soft rot of rhizomes accompanied by an offensive smell.

Source of infection and spread

The disease may be responsible for serious losses in stored ginger. It is generally not a problem in the field as it occurs only in waterlogged soils. The bacteria enter the rhizomes through injuries.

Importance

Can cause serious losses in storage.

Control

If ginger is to be stored for any length of time, the following precautions should be taken.

1. Minimise mechanical damage of the rhizomes at harvest.
2. Do not harvest ginger for storage until the pseudostem junctions have callused.
3. Dry rhizomes before harvest.
4. Store ginger in a cool well-ventilated shed.
5. Store ginger only in new bags.
6. Avoid planting poorly drained areas.

Lettuce

FIELD DISEASES

Bacteria and mycoplasmas

Dry leaf spot

Xanthomonas campestris pv. *vitians*

Symptoms

Leaves: small angular water-soaked spots drying out and becoming light brown and papery. If a large number of spots occurs on a leaf, affected areas become yellow, brown and die.

Source of infection and spread

As lettuce is grown throughout the year, the main source of infection is other diseased plants. However, the bacterium survives on undecomposed lettuce residues in the soil. Cool showery weather favours infection and rapid spread.

Importance

Usually minor but can be severe in wet weather.

Control

Spray with the recommended fungicide, copper hydroxide.

Fungi

Downy mildew

Bremia lactucae

Symptoms

Leaves: light green to yellowish angular spots, later turning brown and sometimes becoming soft and slimy. In moist weather, a white downy fungal growth is present on the underside of the spots.

Source of infection and spread

As lettuce is grown throughout the year, the main source of infection is other diseased plants. The downy growth produced on leaves in moist weather contains large numbers of spores which are spread by wind over long distances. Cool moist weather favours infection and disease development. Downy mildew is generally worst on the lower leaves which are shaded and remain wet for a considerable time after rain, irrigation or heavy dews.

Importance

Can be serious and requires regular spraying. Difficult to control in wet weather.

Control

1. Spray with recommended fungicides.
2. Plough-in old crops immediately after harvest.

Fungicides

Chemicals: metalaxyl + mancozeb.

Begin when the plants have three to four true leaves and continue at 7 to 10-day intervals. Use the shorter interval during wet weather or when dews are heavy. Spray to thoroughly wet plants.

Grey mould

Botrytis cinerea

Symptoms

A soft brown rot of the stem at ground level covered with masses of grey powdery spores. Severely affected plants may die.

Source of infection and spread

The disease is uncommon and is seen only in damp situations during cool, wet weather. The fungus enters mainly through wounds.

Importance

Uncommon.

Control

1. Avoid growing lettuce in damp situations particularly in the cooler months.
2. Spray with the recommended fungicides if the disease threatens.

Fungicides

Chemicals: dicloran, vinclozolin.

Rhizoctonia base rot

Rhizoctonia solani

Symptoms

The disease is most common on advanced plants. The lowest leaves develop brown lesions where they have been in contact with the soil. Lesions usually occur first on the midribs and petioles but later the web of the leaf is also rotted. In severe cases, stem lesions occur at ground level and progress up the plant. Younger leaves are infected through their petioles.

Source of infection and spread

The fungus is a widely distributed soil-borne organism. Severe outbreaks are often associated with large amounts of undecomposed organic matter in the soil.

Importance

Base rot is common in warm weather, especially on heavy soil types.

Control

1. Allow crop refuse to decompose before planting.

2. Use the recommended fungicide (quintozene 120-150 g/100 L) as a full ground spray shortly after planting.

Sclerotinia rot

Sclerotinia sclerotiorum

Symptoms

A soft watery rot generally beginning at ground level and progressing into the head causing the leaves to collapse and die. The head eventually becomes a wet mass of light brown decayed leaves. Affected areas show masses of white fluffy fungal growth and small black irregular resting bodies (sclerotia) of the fungus.

Source of infection and spread

The sclerotia produced in affected tissues may survive in the soil for many years. During moist weather, those near the surface germinate to produce at the soil surface small cream 'mushroom-like' bodies (apothecia) which contain large numbers of ascospores. These are forcibly discharged and carried by wind for long distances. Before the fungus can infect healthy tissues, it must first germinate on and infect dying plant material. It then invades healthy leaves in contact. A large number of other crop plants and weeds are affected by *Sclerotinia* rot.

Importance

Common.

Control

1. Avoid planting infested areas in the cooler months.
2. Avoid wet shady areas.
3. Spray with the recommended fungicides.
4. Dispose of affected crop residues by deep cultivation as soon as the crop is harvested.

Fungicides

Chemicals: benomyl, iprodione, procymidone.

1. Begin at transplanting and continue at 14-day intervals.
2. Generally necessary only in winter crops approaching maturity or where the disease has been a problem previously.

Chemical: vinclozolin.

Apply to point of run-off shortly after transplanting or thinning and then at 10 to 14-day intervals to harvest. Use 750 to 1200 L/ha. Use higher rates when disease pressure is severe.

Septoria spot

Septoria lactucae

Symptoms

On leaves, light brown spots of irregular shape, studded with small black fruiting bodies of the fungus. Spots generally occur on the lower leaves.

Source of infection and spread

As lettuce is grown throughout the year, the main source of infection is other diseased plants. However, the fungus also survives on undecomposed lettuce residues in the soil and may be introduced on the seed. Spores produced in the small black fruiting bodies are spread during wet windy weather.

Importance

Common. Often severe following wet weather.

Control

1. Do not plant lettuce in areas containing undecomposed residues from a previous lettuce crop.
2. Spray with recommended fungicides.

Fungicides

Chemicals: benomyl, mancozeb, maneb + zineb, metiram, zineb.

Begin when the disease is first noticed and continue at 7 to 14-day intervals. Use the shorter interval during wet weather.

Viruses

Lettuce necrotic yellows

Lettuce necrotic yellows virus

Symptoms

A browning of the leaf veins followed by the death of parts of the inner leaves. Affected plants are yellow and stunted with leaves often twisted and lopsided.

Source of infection and spread

The virus is spread from infected sowthistle (*Sonchus oleraceus*) by green aphids which breed on this weed. Outbreaks of this disease are almost always associated with infected sowthistles within or near the crop.

Importance

Can be serious.

Control

1. Destroy milk thistles in and around the crop.
2. Maintain aphid control in crop.

Mosaic

Lettuce mosaic virus

Symptoms

Light and dark green mosaic patterns on leaves, sometimes with vein-browning. Affected plants are stunted, pale in colour, and generally do not produce marketable heads.

Source of infection and spread

The disease generally originates from the use of infected seed. It is then spread by several species of

aphids and may build up very rapidly if a succession of plantings is made.

Importance

Can be serious.

Control

1. Use commercially-produced seed since this rarely carries mosaic.
2. If possible, purchase seed lots of cultivars which have been indexed for freedom from seed-borne mosaic.
3. Destroy old lettuce patches as soon as harvesting is completed.

Spotted wilt

Tomato spotted wilt virus

Symptoms

Affected plants are yellow and stunted and develop a lopsided appearance. Some dark discolouration of the leaves on the stunted side may also occur in older plants. Difficult to distinguish from lettuce necrotic yellows virus.

Source of infection and spread

The virus is spread by thrips, generally from infected weeds growing in the vicinity. The disease is most common in spring and early summer in cooler areas.

Importance

Minor.

Control

Control weeds in and around the crop area.

POST-HARVEST

Bacteria and mycoplasmas

Soft rot

Erwinia carotovora pv. *carotovora*

Symptoms

A soft wet slimy rot of heads.

Source of infection and spread

The bacterium is common in soil, particularly in decomposing plant matter. Decay begins on bruised or damaged leaves often following tipburn and other diseases. It is mainly a post-harvest problem and may be serious in heads harvested when wet in hot weather.

Importance

Serious in summer crops.

Control

1. Avoid marketing heads with severe tipburn and other leaf diseases unless carefully trimmed.
2. Store heads in a cool well-ventilated place.
3. Avoid harvesting in wet weather.

Onions and garlic

FIELD DISEASES

Fungi

Black mould

Aspergillus niger

Symptoms

Black powdery spore masses on the outer scale leaves of bulbs, particularly along the veins.

Source of infection and spread

The fungus is a common soil inhabitant. Spores produced are carried on the surface of the bulbs and mould develops if they are stored for long periods or under poor storage conditions.

Importance

Rare.

Control

Store bulbs under cool dry conditions.

Damping-off

Pythium spp., *Rhizoctonia solani*

Symptoms

A collapse and death of seedlings. May be confused with heat girdle where a scorching of tissue occurs at ground level.

Importance

Minor.

Control

Treat seed with the recommended fungicide.

Seed treatment

Dust seed before planting with thiram dust (800 g/kg) at 2 g/kg of seed. After treatment, screen off excess dust.

Downy mildew

Peronospora destructor

Symptoms

Leaves: lens-shaped spots, sometimes involving a whole leaf, with a blue-grey fungal growth on the surface. However, this may not be obvious in dry weather. Spots may later be covered with a black mould which is a secondary invader. Affected leaves yellow and die.

Seed stalk: large, light green or yellow spots eventually encircling the stalk causing it to break.

Source of infection and spread

The fungus survives from season to season on onion residues in the soil. Large numbers of spores produced by the fungus are spread by wind. Cool wet weather favours infection and disease development.

Importance

Moderate. Necessitates regular spraying with fungicides.

Control

Spray with a recommended fungicide.

Fungicides

Onions

Chemicals: mancozeb, propineb, zineb, mancozeb + metalaxyl.

1. Use either mancozeb, propineb or zineb in a preventative programme at 7 to 10 day intervals.
2. At first sign of disease, apply two sprays of metalaxyl + mancozeb at 7 to 10 day intervals then return to the preventative programme.
3. If downy mildew recurs, and weather conditions are favourable for disease, repeat step 2.
4. A wetting agent should be used to increase spray coverage.

Garlic

Chemicals: metalaxyl + mancozeb.

1. Apply when disease appears and repeat at 7 to 10-day intervals.
2. Add a wetting agent.

Fusarium wilt

Fusarium sp.

Symptoms

Leaves: a yellowing and death of leaves generally commencing with the younger leaves. A wet breakdown at the neck may occur and the bulb often becomes distorted or bloated.

Basal plate and roots: a distinct brown discolouration of the basal plate which is generally more intense in the middle where the oldest roots were formed. Roots are brown and rotted. Both garlic and onions are affected.

Source of infection and spread

The fungus is common in soil where crops have been grown regularly. It may be introduced into new areas on diseased bulbs used as planting material and in infested soil on farm machinery.

Importance

Moderate.

Control

1. Plant disease-free bulbs.
2. Rotate onions with non-susceptible crops.

Macrophomina bulb rot*Macrophomina phaseolina***Symptoms**

An ashy discolouration of the outer scale leaves. Close examination shows the presence of numerous, small, black dots (resting bodies of the fungus) embedded in the affected tissues.

Source of infection and spread

The fungus survives in the soil for many years and affects many other crops including soybeans, sunflowers, maize and sorghum.

Importance

Rare.

Control

Not warranted.

Pink root*Pyrenochaeta terrestris***Symptoms**

Plants: affected plants show unthrifty growth and yellowing, withering and death of leaves which commences from the tips of the older leaves.

Roots: a pink to red discolouration and death first appearing on roots near the centre of the basal plate. Secondary organisms may enter through the damaged tissues and cause bulb rot.

Source of infection and spread

The fungus is a common soil inhabitant and is more active in warm weather. Cereal crops such as maize, sorghum, wheat and barley are alternative hosts.

Importance

Moderate. Limits production to cooler months.

Control

1. Avoid warm weather plantings.
2. Rotate onions with non-susceptible crops.

Purple blotch*Alternaria porri***Symptoms**

Leaves: greyish spots enlarge and become darker in the centre and finally purple. Spots may extend around the leaves causing them to collapse and die.

Source of infection and spread

The fungus survives on onion residues and is spread during wet windy weather.

Importance

Minor.

Control

Spray with recommended fungicides.

Fungicides**Onions**

Chemicals: mancozeb; zineb.

1. Apply at the first sign of disease and repeat at 7 to 10-day intervals.
2. Add a wetting agent.

Garlic

Chemicals: metalaxyl + mancozeb.

1. Apply when disease first appears and repeat intervals of 7 to 10 days.
2. Add a wetting agent.

Rust*Puccinia allii***Symptoms**

Small yellow pustules appear first on the undersides of leaves. These develop in size and the surrounding tissue dies. Pustules later develop on both surfaces and are filled with black masses of spores. Serious incidence causes death of leaves.

General

The fungus has been found on garlic, shallots and onions in Queensland. The disease is favoured by warm, moist weather and spreads rapidly under these conditions.

Importance

Moderate. Necessitates regular spraying with fungicides.

Control

1. Spray with recommended fungicides.
2. Control volunteer plants.
3. Rotate planting sites.

Fungicides

Chemicals: zineb + copper oxychloride.

1. Apply when disease first appears and repeat at 7 to 10-day intervals.
2. Add a wetting agent.

Smudge*Colletotrichum circinans***Symptoms**

Small, round, dark blotches, often with a zonate pattern on the outer scale leaves of the bulb.

Source of infection and spread

The fungus survives in the soil on onion residues. Spores are carried on the surface of the bulb when harvested and symptoms develop if they are stored for long periods or under poor storage conditions.

Brown skinned types are highly resistant to smudge.

Importance

Rare.

Control

Store bulbs under cool dry conditions.

White rot

Sclerotium cepivorum

Symptoms

Plants die out in small patches which extend slowly, often advancing only half a metre in a season. When affected plants are removed from soil, white wefts of fungal growth will be seen on the bulbs and roots. This growth causes soil particles to adhere to the affected areas. Small dark brown spherical resting bodies (sclerotia) of the fungus are embedded in the tissues.

Source of infection and spread

The sclerotia enable the fungus to survive in the soil for long periods. In cool weather, the fungus grows through the soil, invading any bulbs which it contacts. Spread over longer distances may occur with infested soil and with diseased bulbs used for planting. If affected bulbs are packed, extensive breakdown may occur during transit and storage.

Importance

A major disease.

Control

1. Do not plant onions or garlic in affected areas for at least five years.
2. Do not retain bulbs from a diseased crop for planting.
3. Do not pack diseased bulbs.

Viruses**Mosaic - garlic**

Virus - undetermined

Symptoms

Yellow flecking, blotching and streaking of leaves. Affected plants are generally stunted.

General

The virus may be carried from one season to the next in diseased cloves and is spread from plant to plant by aphids. Most garlic plants are affected.

Importance

Present in all crops but effect on yield has not been determined.

Control

No recommendations at this stage.

POST-HARVEST**Grey mould**

Botrytis sp.

Symptoms

A breakdown of the cut neck and other parts of the bulb accompanied by the production of a dense layer of grey furry mould. Hard black resting bodies (sclerotia) of the fungus may become matted around the rotted neck.

Source of infection and spread

The fungus survives in the soil as sclerotia or on onion residues. Spores produced are spread by wind. Infection occurs at harvesting through the cut neck but may also develop through other injuries to the bulb. Breakdown then occurs during storage, although this may be quite slow. Under humid storage conditions, spread to other bulbs by contact may be quite extensive.

Importance

Minor.

Control

1. Harvest at the correct stage of maturity.
2. Handle bulbs carefully to reduce injury.
3. Hold bulbs under dry conditions to cure the neck quickly or artificially dry.
4. Store bulbs under cool dry conditions.

Storage rot

Various fungi

Symptoms

A soft wet breakdown of stored onions with an offensive smell. This disease is generally caused by unsuitable storage conditions or storing poor quality or damaged bulbs.

Importance

Minor.

Control

1. Store only properly matured sound onions.
2. Store bulbs under cool dry well-ventilated conditions or cold store bulbs.

Peas

FIELD DISEASES

Fungi

Black root rot

Aphanomyces euteiches

Symptoms

Symptoms are not usually seen until a few weeks after planting. Affected plants lack vigour and their root systems and lower stems are discoloured light brown. The colour later changes to a dark brown or black and the outer root tissues become soft. Leaves wilt and shrivel progressively from the base. Provided moisture is adequate, plants do not usually die before setting a reduced crop. The disease is often uniformly distributed through a field with most plants being affected. With no ready comparison between healthy and diseased plants the symptoms are often misdiagnosed as due to moisture stress.

Source of infection and spread

The fungus is a soil inhabitant favoured by wet conditions. There are two spore types. A resting spore is produced in diseased tissue which serves to maintain the presence of the organism in the soil for several years. Transport of this spore with crop remains or soil will extend the affected area. A second spore type is produced during the growing season and travels in water spreading the disease from plant to plant.

Importance

Widespread and severe in south Queensland pea crops.

Control

1. Avoid poorly drained areas.
2. Use long rotations between pea crops.

Downy mildew

Peronospora viciae

Symptoms

The fungus may cause local lesions or invade the whole plant systemically. Local lesions are seen as yellow spots on leaves with a thick grey-brown fungal growth on the under surface following moist conditions. Systemic infection leads to stunted plants with severely deformed leaves which also have a profuse development of the grey-brown fungal growth on the under surface.

Source of infection and spread

The fungus produces two spore types. One is a resting spore which is embedded in infected plant material and serves as inoculum for future crops. The

other is a wind-dispersed spore produced in large numbers during periods of high humidity. This spore forms part of the fungal growth on affected tissues. Severe outbreaks of the disease depend on showery weather.

Importance

Widespread. Commonly found affecting seedling leaves. Not usually severe on mature plants excepting those with systemic infection.

Control

Use crop rotation to lower soil-borne inoculum. Spray with a recommended fungicide.

Fungicide

Chemical: zineb.

Leaf, stem and pod blight

Ascochyta pisi, *Mycosphaerella pinodes*

Symptoms

These two related fungi cause spots on leaves, stems and pods. Lesions caused by *Ascochyta pisi* are generally light in colour with a distinct darker margin. Those caused by *Mycosphaerella pinodes* are brown to purple with indefinite margins. The size of lesions varies considerably with weather conditions, ranging from small flecks to stem lesions several centimetres long. Blight can be very severe in crops with a dense canopy which provides the conditions of high humidity which favour disease development.

Source of infection and spread

The fungi may be carried on the seed or survive on residues from previous pea crops. Spores may be carried long distances by wind but severe disease outbreaks follow showery weather.

Importance

Occurs widely but usually not severe.

Control

1. Plough-in residues promptly after harvest and employ crop rotation to avoid carryover of inoculum in the soil.
2. Treat seed with the recommended fungicide.

Seed treatment

Thiram plus thiabendazole seed dressing at 150 g/100 kg seed.

Powdery mildew

Erysiphe polygoni

Symptoms

The disease generally occurs first on the lower leaves. The early stage is difficult to see since the fungus

grows on the surface of the leaves without killing the leaf tissue. Infected portions of the leaf are slightly off-colour and if held to catch the light the white thread-like growth of the fungus may be seen on the surface. In later stages of development the disease is easily recognised by the white powdery growth which covers affected areas.

Severely affected leaves eventually die. Pod infection leads to a grey-brown discolouration of the seeds.

Source of infection and spread

Powdery mildew survives by growing on a succession of crops or volunteer pea plants and on infected plant debris. There is also the possibility of seed-borne transmission. Once established the fungus spreads rapidly by the large numbers of air borne spores produced on infected plant parts.

Warm, dry days with cool, moist nights are most favourable for disease development. Water stressed crops also seem more susceptible to severe damage.

Importance

Widespread and severe.

Control

1. Early season plantings are generally less affected than later plantings.
2. Some cultivars with resistance are becoming available.
3. Spray with the recommended fungicide.

Fungicide

Benomyl (500 g/kg) at 0.5 kg/ha or triadimefon (125 g/L) at 0.5 L/ha.

Spray at early flowering and 10 to 14 days later if necessary.

Potatoes

FIELD DISEASES

Bacteria and mycoplasmas

Bacterial wilt

Pseudomonas solanacearum

Symptoms

Plants: a sudden wilting of leaves generally without preliminary yellowing. If the stem is cut at ground level, a whitish exudate may be seen on the cut surface.

Tubers: a wet breakdown at the point of attachment and at the eyes. A milky bacterial exudate is often visible at the eyes, hence the name 'milky-eye'. The disease can be recognised if a tuber is cut across. In affected tubers, a light brown breakdown of the water-conducting tissues will be seen. Milky fluid may be squeezed from this discoloured area.

Source of infection and spread

The bacterium is a soil inhabitant and survives in soil for many years. It may be introduced with seed. Infection occurs through the seedpiece or roots, the bacteria moving into the water-conducting tissues. Hot weather favours disease development. The bacterium may be spread with infested soil. Tomatoes and capsicums are also affected.

Importance

Minor.

Control

1. Use certified seed.
2. Grow crops which are not hosts of the pathogen for a number of years before replanting potatoes.

Black leg

Erwinia carotovora pv. *atroseptica*

Symptoms

Plants: a stunting and wilting of plants often before flowering. The seedpiece is rotted and the stem has a black wet rot often extending above ground level. Water-conducting tissues above the rot are discoloured black. Affected plants die.

Tubers: externally, a brown wet rotted area with a black margin may be seen around the point of attachment. Internally, affected tissues are soft and discoloured with a black margin, extending in from the point of attachment.

Source of infection and spread

The bacterium is generally introduced with seed. After breakdown of the seedpiece, it enters the

water-conducting tissues to cause breakdown of the stem and eventually the tubers.

Importance

Minor. Often a high incidence in imported seed.

Control

1. Use certified seed.
2. Take measures to minimize seedpiece breakdown.

Purple top wilt

Mycoplasma-like organism

Symptoms

At first an upward rolling of young leaves generally at flowering. Affected plants become stiff and erect and develop yellow or purple discolourations at the base of young leaflets. Internodes are shortened giving a rosette effect.

Aerial tubers may form in the leaf axils. Seedpieces of affected plants are generally rotted and water-conducting tissues discoloured. Tubers may be flabby and fail to sprout, or produce spindle sprouts which do not develop into plants.

Source of infection and spread

Purple top wilt (sometimes called autumn wilt) is most serious in autumn plantings. Mycoplasma-like organisms, which are spread by leafhoppers, have been implicated as a cause of purple top wilt disease. However, some or all of the symptoms described above may be caused by other factors.

Importance

Moderate in autumn crop. Minor at other times.

Control

None available.

Soft rot

Erwinia carotovora pv. *carotovora*

Symptoms

A soft breakdown of tubers with an offensive smell. Rotted tissues are generally not discoloured.

Source of infection and spread

Breakdown may occur in the field under warm waterlogged soil conditions or during transit and storage. It is often serious where tubers have been washed. The bacteria enter the tubers through lenticels or cuts, abrasions or bruises to the skin.

Importance

Moderate.

Control

1. Ensure adequate crop drainage.

2. Avoid mechanical damage to tubers during harvesting.
3. Store tubers under cool well-ventilated conditions.

Fungi

Anthracnose

Colletotrichum atramentarium

Symptoms

A slow wilting of plants with some yellowing of the older leaves. Young leaves may show vein death, interveinal scorching and rolling of the leaf margin. Below-ground, the lower stem may be dry and shredded with small black fruiting bodies embedded in the tissues.

Source of infection and spread

The fungus is a soil inhabitant and is very common on tubers. It invades the plant generally after seedpiece breakdown. When this occurs early in the life of the crop, the disease may cause significant loss. However, infection often occurs as the plants mature and is then of little importance.

Importance

Minor.

Control

Take measures to minimise seedpiece breakdown.

Armillaria rot

Armillaria luteobubalina

Symptoms

Black string-like fungal strands on stems and tubers.

Source of infection and spread

This disease is generally a problem only where forest areas have been cleared for cultivation, as the fungus survives on stumps and roots of trees. It grows out through the soil, invading tubers and stems which it contacts.

Importance

Rare. Only seen in crops grown in recently cleared land.

Control

Before planting potatoes in newly cleared land, ensure that all tree stumps and large roots have been removed.

Common scab

Streptomyces scabies

Symptoms

On tubers, unsightly corky areas which may develop into deep pits.

Source of infection and spread

The fungus is common in potato-growing soils where it may survive for many years. It is also introduced with seed. Spread occurs with infested soil. The disease is generally not serious where adequate water is provided when tubers are forming.

Importance

Minor.

Control

1. Do not plant diseased seed.
2. Apply adequate water during tuber formation.

Fungicide dip of seed

For control of black scurf, common scab, powdery scab, *Fusarium* and *Phoma* dry rot and silver scurf. As soon as possible after receipt or removal from store, sort out and discard obviously affected tubers. Damp the rest for 24 hours before dipping to improve control of black scurf. Dip in methoxyethyl mercuric chloride (120 g/L) at 125 mL/100 L with a wetting agent. After dipping 100 kg of seed, top up the dip with 3 L of a double strength solution (250 mL/100 L) of the fungicide with wetting agent added at the normal rates. Discard the dip completely after treating one or two tonnes of seed.

Note:

1. Do not feed treated tubers to animals or use for human consumption. Bury seed that is not used for planting.
2. Dip before sprouting as the fungicide may injure sprouts.

Dry rot

Fusarium spp., *Phoma* spp.

Symptoms

Fusarium rot: a dry sunken rot often giving tubers a wrinkled appearance. Pockets within the rot are generally filled with white or pink wefts of the fungus. This may sometimes be present on the outer surface. If the rot commences around the point of attachment, it is known as stem-end rot and indicates the presence of *Fusarium* wilt in the parent crop.

Phoma rot: shallow thumb-mark depressions with small pinpoint black dots (fruiting bodies) on the surface.

Source of infection and spread

The fungi are common soil inhabitants which enter the tuber through wounds. As the rot develops slowly, it is generally seen only after potatoes have been stored for some time. In Queensland, table potatoes are seldom stored for long periods and the disease is confined mainly to seed consignments. High storage temperatures favour disease development. If affected seed is planted, a poor stand generally results.

Importance

Minor.

Control

1. Inspect seed consignments on arrival and reject those affected.
2. Store consignments under cool well-ventilated conditions.
3. Reject affected tubers before cutting.

Fungicide dip of seed

Refer to the common scab control section above.

Treatment of potatoes prior to storage (for control of dry rot and silver scurf).

Treat potatoes as soon as possible after harvesting with thiabendazole (450 g/L) at a rate of 1 L/20 L of water/10 t of potatoes. Apply as a mist over the potatoes on the conveyor line. Ensure even and complete coverage by adequate rotation of the tubers but minimise moistening.

Fusarium wilt and stem-end rot

Fusarium spp.

Symptoms

Affected plants may yellow, wilt and die. Initially only one stem of the plant may show symptoms. The seedpiece will probably have decayed and the lower stem will show a dry rot. The water-conducting tissues of the stem may be discoloured brown.

The fungus may progress along the stolons to infect newly developed tubers and cause stem-end rot. Water-conducting tissues of these tubers may show a brown discolouration. The fungus may also cause a rot of tubers in storage known as dry rot.

Source of infection and spread

The fungus is a soil inhabitant but may be carried in seed.

Importance

Minor. More prevalent in warmer areas.

Control

1. Plant certified seed.
2. Before planting, remove tubers showing symptoms of dry rot.
3. Rotate potatoes with other crops.
4. Early digging and use of a desiccant to hasten death of the tops may restrict development of stem end rot.

Irish blight

Phytophthora infestans

Symptoms

Leaves and stem: large pale green areas with an indefinite margin becoming water-soaked and dark in colour. A whitish downy 'fuzz' may be visible on affected areas in moist weather.

Tubers: slightly sunken areas of dark rotted tissue.

Source of infection and spread

The fungus survives on potato residues but is generally introduced with seed. Large numbers of spores are produced in the downy 'fuzz' on affected areas and are spread by wind, rain or irrigation water. Cool wet weather favours infection and rapid development of the disease.

Importance

Causes only foliage damage mainly due to the use of resistant cultivars. The spray schedule recommended for target spot gives useful control (see p. 56).

Control

1. Spray with recommended fungicides.
2. Plant resistant cultivars.

Fungicides

Refer to the section on target spot (see p. 56).

Cultivars

Tubers: Sebago, Sequoia, Exton, Kennebec, Kurrel and Bungama — resistant; Pontiac — susceptible. Foliage: Kennebec — resistant; Sebago, Sequoia, Exton, Kurrel, Bungama and Pontiac — susceptible.

Note: Cultivars should not be selected on the basis of disease reaction only. Some may be unsuitable for your district for other reasons. Always consult your local extension officer. For best results, use certified seed on ground that at least has not grown more than two crops of potatoes in five years.

Powdery mildew

Oidium spp.

Symptoms

A white dry powdery growth on leaves and stems. Leaf rolling and sunburn may follow.

General

The disease is more common in dry seasons.

Importance

Rare.

Control

Not warranted.

Powdery scab

Spongospora subterranea

Symptoms

On tubers, raised wart-like growths eventually breaking open into sunken scabs fringed with torn tuber skin. The tissue within the scabs is dry and powdery. Scabs are often more numerous at the stem-end.

Source of infection and spread

The fungus is generally introduced with seed but, once established in the soil, may survive there for many years. Large numbers of spores produced in the scabs are spread by water or with infested soil. The disease is a problem only in cool weather, late spring and autumn crops being unaffected. It is also most severe in wet areas of the field, or in crops which have been heavily watered to reduce frost injury. The fungus is not active in acid soils with a pH below 4.5.

Importance

Severe in winter crops.

Control

1. Plant disease-free seed.
2. Plant resistant cultivars.
3. Do not apply lime before growing a winter crop of potatoes in light acid soils.
4. The use of fungicides for *Rhizoctonia* rot control may reduce the fungus on the seed (see p. 54).

Cultivars

Exton and Kurrel — resistant; Sebago and Bungama — partially resistant; Sequoia, Kennebec and Pontiac — susceptible.

Note: Cultivars should not be selected on the basis of disease reaction only. Some may be unsuitable for your district for other reasons. Always consult your local extension officer. For best results, use certified seed on ground that at least has not grown more than two crops of potatoes in five years.

Fungicide dip of seed

Refer to the common scab control section (see p. 52).

Fungicide soil treatment

Apply quintozene (750 g/kg) at a rate of 44 kg/ha as a row treatment in a 300 mm band incorporating 100 to 140 mm deep with a rotary hoe. Cover seed with treated soil only. Do not apply quintozene directly to seed.

Pythium rot

Pythium ultimum

Symptoms

Tubers develop a soft rot and complete rotting of the tuber may occur in a few days. There is usually no discolouration of affected tissue.

Source of infection and spread

The fungus is a water mould and needs free water to spread and infect tubers. Infection also occurs following injury at harvest.

Importance

Minor.

Control

1. Ensure adequate drainage of fields.

2. Reject tubers showing soft rot at harvest.

3. Store tubers under cool well-ventilated conditions.

Rhizoctonia rot (black scurf)

Rhizoctonia solani

Symptoms

Stems: dry brown sunken spots sometimes girdling the stem. Young sprouts may be killed before emergence.

Tubers: small raised black fungal bodies (sclerotia), firmly attached to the surface. These are sometimes mistaken for soil particles and are most obvious when the tuber is wet.

Source of infection and spread

The fungus is a common soil inhabitant and is very active in decaying plant material. It may also be introduced with seed. Many crop plants are susceptible to this fungus.

Importance

Minor. Higher incidence in imported seed. *Rhizoctonia* rot is generally a problem only where seed crops are ground stored for sometime.

Control

1. Prepare land early so that crop residues have ample time to decompose.
2. Do not plant severely affected tubers.
3. Dip other affected tubers in the recommended fungicide before cutting and/or planting.

Fungicide dip of seed

Refer to the common scab control section (see p. 52).

Tuber treatment at planting for *Rhizoctonia* rot control. Apply tolclofos-methyl to seed pieces at 2 kg/tonne of seed as the hopper is being filled for planting. Do not apply to freshly cut seed potatoes as emergence may be affected. Refer to label for general instructions on use.

Note: Do not feed treated tubers to animals or use for human consumption. Bury seed that is not used for planting.

Sclerotinia rot

Sclerotinia sclerotiorum

Symptoms

A wet rot of stalks which later dry out and become bleached. If these stalks are broken open, a cottony white fungal growth and large black irregular, resting bodies (sclerotia) of the fungus will be seen.

Source of infection and spread

The sclerotia formed in affected tissues may survive in the soil for many years. During cool moist weather those near the surface germinate to produce at the soil surface small cream 'mushroom-like' bodies (apothecia). These contain large numbers of ascospores which are forcibly discharged and carried by wind.

Infection occurs at points of injury or where dead flowers and leaves remain in contact with healthy tissues. Cool showery weather favours the disease but fogs, mists, dew and irrigation provide enough moisture for infection.

Importance

Rare.

Control

Avoid planting infested areas in the cooler months.

Fungicide

Chemical: benomyl.

Begin spraying at flowering and continue at 14-day intervals as required.

Sclerotium rot

Sclerotium rolfsii

Symptoms

Seedlings may wilt and die from a conspicuous white rot of the root and crown. Older plants when affected are stunted with firing of the older leaves and rolling, bleaching and wilting of young leaves. The lower leaf sheaths, particularly those at and below the soil surface, are cemented to the stalk by a mantle of white fungal growth. White strands may also be seen on the roots and in adhering soil. When the leaf sheaths are stripped from the plant, a brown streaking may be seen on the stalk extending upward through several internodes.

In advanced stages, the internal tissues in the base of the stalk are completely rotted and white fungal growth occupies the cavity. Mushroom-like fruiting bodies of the fungus may develop on affected areas and a strong mushroom odour is present.

Source of infection and spread

The fungus is present in many soils used for maize growing in north Queensland. It is particularly common where maize has been grown continuously for some years. The fungus has also been found on teosinte, nut grass, sorghum, Johnson grass and guinea grass. Hot dry weather favours the disease and it is most serious in seasons with below average rainfall.

Importance

Minor.

Control

Harvest as soon as tubers are mature.

Seedpiece breakdown

Symptoms

A rotting of the seedpiece followed by a brown discolouration and rotting of the lower stem and roots. Plants may fail to emerge or produce weak shoots, but often no evidence of the disease can be seen above-ground.

Source of infection and spread

Seed consignments differ in their susceptibility to seedpiece breakdown. This is affected by the growing conditions of the seed crop, storage conditions, length of storage and handling. Susceptible consignments do not withstand cutting injury and are then easily rotted by soft-rotting organisms. Although affected plants may emerge normally, the rotted seedpiece provides easy access to the stem for wilting organisms, particularly *Fusarium* spp., *Rhizoctonia solani* and *Colletotrichum atramentarium*. Early death follows.

Importance

Major.

Control

1. Avoid long storage of seed.
2. Recondition cold-stored seed at normal temperatures for two to three weeks.
3. Cut in the shade under cool conditions.
4. Treat cut seed with the recommended fungicide.
5. Hold treated seed under well-ventilated conditions.
6. Plant into moist soil soon after cutting and do not irrigate before emergence.

Fungicide treatment of cut seed (to prevent seedpiece breakdown).

As soon as possible after cutting, dust the entire surface of the seedpieces with mancozeb (200 g/kg) potato dust used at a rate of 200 to 400 g/100 kg of seed.

Note: Plant as soon as possible after treatment. Do not feed treated seed to animals or use for human consumption. Bury seed that is not used for planting.

Silver scurf

Helminthosporium solani

Symptoms

On tubers, more or less circular superficial brown spots which darken with age. The spots may not be conspicuous on dry tubers but, when tubers are wet, they have a characteristic silvery appearance. Affected areas may dry and slough off allowing water loss during storage with the result that tubers become shrivelled and wrinkled.

Source of infection and spread

The fungus may survive from season to season in the soil or be introduced on diseased seed. As it causes superficial damage only, it has little effect on marketability.

Importance

Rare.

Control

Dip seed in the recommended fungicide before planting.

Fungicide dip of seed

Refer to the common scab control section (see p. 52).

Treatment of potatoes prior to storage (for control of dry rot and silver scurf).

Treat potatoes as soon as possible after harvesting with thiabendazole (450 g/L) at a rate of 1 L/20 L of water/10 t of potatoes. Apply as a mist over the potatoes on the conveyor line. Ensure even and complete coverage by adequate rotation of the tubers but minimise moistening.

Target spot

Alternaria solani

Symptoms

On leaves, small round brown to black spots up to 20 mm wide, often with a marked zonate pattern. Spots are frequently delimited by the veins, giving them an angular shape. When the disease is severe, plants are often defoliated.

Source of infection and spread

The common sources of infection are diseased plants and residues of tomatoes and potatoes. Spores produced on the spots are spread by wind, rain or irrigation water. Warm weather favours disease development.

Importance

Major. Necessitates regular spraying with fungicide.

Fungicides

Chemicals: chlorothalonil, copper oxychloride, cuprous oxide, copper oxychloride-zineb combination, mancozeb, metalaxyl + mancozeb, metiram, zineb.

1. Begin spraying when plants are 150 to 190 mm high and continue spraying at 7 to 10-day intervals. Use shorter interval when prolonged wet weather occurs.
2. Copper oxychloride or combinations are least preferred but as they weather well they are useful when spray retention is a problem, for example where crops are watered frequently.
3. With high volume spray equipment, use approximately 1000 L/ha.
4. Read labels carefully for instructions on wetting agents, compatibility with other products and cautions on mixing and spraying.

Cultivars

Sequoia and Kurrel — partially resistant; Kennebec and Pontiac — highly susceptible; Sebago, Exton and Bungama — susceptible.

Note: Cultivars should not be selected on the basis of disease reaction only. Some may be unsuitable for your district for other reasons. Always consult your local extension officer. For best results, use certified seed on ground that at least has not grown more than two crops of potatoes in five years.

Verticillium wilt

Verticillium dahliae

Symptoms

Affected plants wilt slowly and die prematurely. A close examination of plants shows death of the older leaves and yellowing of the middle leaves. One side of the plant may be more severely affected than the other. Water-conducting tissues of the stem may be discoloured brown. Affected tubers may show a dark discolouration of the water-conducting tissues, particularly near the point of stolon attachment.

Source of infection and spread

The fungus is a soil inhabitant occurring naturally in many soils. It may also be carried in or on seed potatoes. Many cultivated plants and weeds are susceptible. The disease is more common in the autumn crop.

Importance

Serious in autumn crops. Often limits crop production where rotations are not possible.

Control

1. Do not plant affected seed.
2. Rotate infested soils to cereals or green manure crops.

Nematodes

Pimple

Pratylenchus brachyurus

Symptoms

Areas of dead tissue form around the lenticels of tubers. In extreme cases, much of the surface may be affected. The damage does not extend beyond a depth of 2 to 3 mm. This disease may be confused with common scab or powdery scab.

General

The disease has been seen only where potatoes have been grown after pastures.

Importance

Minor.

Control

Not warranted. If the disease has been a problem, avoid cover cropping with cowpea or maize which are good hosts of the nematode.

Root-knot nematodes

Meloidogyne spp.

Symptoms

Galls on the roots and swellings on the surface of the tubers. When the latter are peeled, small translucent areas about the size of a pin head are seen in the tissue.

Source of infection and spread

Root-knot nematodes are common, even in virgin soil. Larvae invade root tips and the breathing pores (lenticels) of the tubers. Potato seed is frequently infested with root-knot nematodes.

Importance

Moderate on light soils, particularly in crops planted in summer to early autumn.

Control

1. Plant nematode-free seed.
2. Use a recommended nematicide before planting infested areas.
3. Do not grow susceptible green manure crops, particularly cowpeas, in infested areas.

Preplant soil treatment

Apply one of the following treatments when planting infested areas.

Chemical: ethylene dibromide (EDB).

Apply at recommended label rates to achieve 110 kg EDB/ha. Inject the liquid through tines 300 mm apart, at the rate of 66 mL of diluted product/10 m of row. Seal the surface after injection by light rolling or a light spray irrigation. Leave the soil undisturbed for 7 to 14 days then cultivate to aerate it. For best results, soil should be free from undecomposed organic matter, warm and moist. If the soil is too wet, the fumigant does not diffuse properly and, if too dry, diffusion from the soil is too rapid.

Chemical: fenamiphos.

Treat the soil 1 to 7 days before planting with fenamiphos (400 g/L) applied as a row treatment at the rate of 13 L/ha. Rows are 800 mm apart, 110 mL/100 m of row. Apply spray at 150 to 200 KPa to a 450 mm band over the row and then mechanically incorporate.

For red volcanic soils only. Apply fenamiphos as soon as sufficient plants have emerged to indicate row position. Apply to moist soil and irrigate immediately after application.

This nematicide is extremely dangerous. Follow directions on label.

Viruses

Calico

Alfalfa mosaic virus

Symptoms

Irregular, bright yellow blotches on middle and younger leaves. As plants mature, symptoms become more intense and cover large portions of the leaves. Affected plants are often stunted.

Source of infection and spread

The virus has a wide host range among crop and weed species and is spread by aphids.

Importance

Minor.

Control

Not warranted.

Leaf roll

Potato leaf roll virus

Symptoms

Plants grown from diseased tubers show an upward rolling of the leaf margin, starting with the lower leaves and progressing upward. Leaves are harsh in texture. Younger leaves become erect and pale in colour and cut tubers may show an internal net browning.

Plants affected during the season show similar leaf symptoms except the younger leaves first show rolling, particularly at the base of the leaflets.

Source of infection and spread

The virus can be introduced in seed but may persist in self-set plants from a previous crop. Older infected crops can act as a source of infection for young crops. The virus is spread by aphids.

Importance

Major in both autumn and spring crops.

Control

1. Use certified seed.
2. Control aphids.
3. Avoid growing young crops near older infected crops.

Mosaic

Potato virus X

Symptoms

No symptoms are produced on cultivars grown in Queensland. However, if diseased seed is planted, yields may be reduced and the combination of this virus with potato virus Y to produce rugose mosaic may cause serious losses.

Source of infection and spread

The incidence of the virus in certified seed is low. However, it is very infectious and is spread by mechanical contact between diseased and healthy plants.

Importance

Rare.

Control

Plant certified seed.

Rugose mosaic

Potato viruses X and Y

Symptoms

Affected plants are stunted with death of older leaves and reduction in the size of younger leaves. On the underside of the leaves, the veins show dead areas and the leaves become distorted and puckered with down-curved margins.

General

The disease may be serious when diseased seed is planted.

Importance

Rare.

Control

Plant certified seed.

Spotted wilt

Tomato spotted wilt virus

Symptoms

Small dead spots, often crescent-shaped, on young leaves. Circular or lens-shaped rings of discoloured tissue may appear on young stalks. Plants are stunted if infected early.

Source of infection and spread

The virus is common in many weeds and crop plants and is spread by thrips. It is generally confined to the outer rows of a crop.

As tubers from affected plants generally fail to shoot, the disease is self-eliminating.

Importance

Rare.

Control

Growers saving seed from a crop should rogue any suspicious plants before harvesting.

Sweet corn

FIELD DISEASES

Fungi

Boil smut

Ustilago zeae

Symptoms

The fungus attacks any above-ground part of the plant which is actively growing, to form swellings referred to as boils, blisters or galls. These are most common on cobs, stems (even at ground level) and tassels, but also develop on leaves. Young galls are covered by a thin white membrane. This encloses a dark brown to black mass of spores which is exposed when the membrane ruptures. Mature galls are up to 200 mm in diameter.

Source of infection and spread

Ruptured galls release spores (chlamydospores) which can be spread by wind, with seed or stock food and in soil adhering to clothes, vehicles, farm machinery and animals. Chlamydospores may survive in the soil for many years, and under favourable temperatures (25°C-34°C) produce aerial spores (sporidia) which are spread by air currents and rain splash. The sporidia germinate, infect young tissues of the host plant and stimulate the host cells to proliferate and form galls.

Importance

First recognised in Queensland in 1982. Disease occurrence is usually sporadic and minor. However, high incidences can occasionally occur in crops.

Control

Growers can reduce the build-up of smut spores in the soil by removing galls from diseased plants before they break open and release spores. Inspections are best carried out after cobs have reached full size. Particular attention should be paid to cobs and stems. Galls should be removed with adjacent cob, stem, tassel or leaf and placed in a plastic bag. Bags containing diseased material should be taken to a site adjacent to crop, drenched in diesel and burned. Any unburnt maize material in the ashes should be refired.

Common rust

Puccinia sorghi

Symptoms

Leaves: oval to elongate, reddish-brown pustules up to 2 mm long, in scattered groups over the surface. Leaf spots develop when the tissue around clusters of pustules dies.

Source of infection and spread

The fungus survives on diseased sweet corn or maize residues and volunteer plants. Large numbers of spores are produced in the pustules and these are spread by wind over long distances. Warm humid weather favours leaf infection, disease development and spore production.

The disease generally appears after tasselling and does not become severe until grain filling is complete. However, if warm wet weather occurs during the grain filling period, yield may be reduced.

Importance

Moderate.

Control

1. Destroy volunteer plants before sowing.
2. Early planting avoids high disease levels.
3. Plant resistant cultivars.

Java downy mildew

Peronosclerospora maydis

Symptoms

Downy mildew infects sweet corn systemically and the symptoms are often mistaken for viral or nutritional disorders. On young plants, the basal section of leaves are chlorotic and often covered with a white downy growth, while on older plants, yellowing occurs in stripes with distinct borders. Other symptoms include multiple sterile cobs, deformed tassels and cobs, leaf-like tassels and cobs, and stunted or elongated stems.

Source of infection and spread

Java downy mildew survives in living host plants, which include maize, sweet corn and *Sorghum plumosum*, a native grass. The disease is spread over short distances by spores (conidia) which form on the leaves of young, infected plants with dew. Sequential plantings of sweet corn in areas where downy mildew is prevalent, allow the disease to build up.

Importance

The disease has only been recorded from northern Australia and was first recognised on the Atherton Tableland in 1985. Incidence can be high in unprotected crops growing near native grasses in far north Queensland.

Control

To protect the crop against infection, treat seed with a slurry of metalaxyl (APRON 350SD®) at the rate of 400 g/100 kg of seed/750 mls water.

Tropical (polysora) rust

Puccinia polysora

Symptoms

Leaves: small round reddish-brown pustules distributed relatively uniformly over the surface. Severely affected leaves die prematurely. Pustules produced on mid-veins and leaf sheaths are larger than those on the leaf and irregular in shape.

Source of infection and spread

The fungus survives on volunteer maize and sweet corn plants. The spores can be spread by wind over long distances. Warm wet weather favours spread.

Importance

Tropical rust has only been recorded in north Queensland. The disease has potential to defoliate sweet corn.

Control

Use resistant cultivars, such as Kulara and Mapee.

Turcicum leaf blight

Exserohilum turcicum

Symptoms

Leaves: long spindle-shaped greyish-green water-soaked spots which often exceed 100 mm in length but are seldom more than 20 mm wide. Under very favourable conditions, spots coalesce to cause blighting of almost the entire leaf. In moist weather, dark masses of spores are produced on the dead areas. Symptoms generally appear after tasselling but, in very wet weather, infection may occur earlier and cause serious reduction in yield.

Source of infection and spread

The fungus survives on diseased sweet corn or maize residues and volunteer plants. Spores are spread by wind and rain. Warm wet weather favours infection and disease development.

Importance

Serious in summer, particularly during warm wet weather or where successive plantings are made.

Control

1. Plant resistant cultivars.
2. Destroy volunteer plants before sowing.
3. Early planting avoids high disease levels.

Cultivars

The cultivars Kulara and Mapee, released by QDPI, are resistant to Johnson grass mosaic virus, turcicum leaf blight, common rust and tropical rust. They are recommended for situations where the risk of these diseases is high.

Viruses

Maize dwarf mosaic

Johnson grass mosaic virus

Symptoms

Mosaic and ringspot patterns on the leaves. Mosaic symptoms consist of light and dark green patches, usually in the form of broken lines between the veins. Very susceptible cultivars show extensive leaf yellowing. Early infection often results in severe stunting and considerable yield reduction.

Source of infection and spread

Johnson grass is the common perennial host of the virus. It also survives in stand-over or ratooned forage and grain sorghum crops. The virus is spread by several species of aphids. As these insects feed for only short periods, insecticides are of little value in disease control.

Importance

Serious in summer.

Control

1. Plant resistant cultivars.
2. Spring plantings usually avoid high disease levels.

Cultivars

The cultivars Kulara, Tropicorn and Mapee, released by QDPI, are resistant to Johnson grass mosaic virus.

Maize stripe disease

Planthopper transmitted virus

Symptoms

On young leaves, light specks which elongate, broaden and fuse in subsequent growth to form light yellow stripes parallel to the midrib. The stripes may extend into broad, white or yellow bands. Affected plants are often bent over at the apex and those infected at an early growth stage are usually stunted.

Source of infection and spread

The virus persists from season to season on volunteer maize plants, sorghum and wild sorghums. It is transmitted by the maize planthopper (*Peregrinus maidis*).

Importance

Generally not serious.

Control

Not generally warranted.

Wallaby ear

Note on cause

The disease was thought to be due to virus infection. It is now known that the symptoms result from a toxin

injected by leafhoppers (*Cicadulina bimaculata*) while feeding.

Symptoms

Leaves of affected plants are dark green and remain at an angle to the stalk. This is probably because of the stiffening produced by the enlarged protruding leaf veins. Affected plants may be severely stunted, particularly if the leafhoppers are present during the early stages of growth.

Source of infection and spread

The small, pale coloured leafhopper (*Cicadulina bimaculata*) is common on maize and sweet corn, particularly in coastal districts during late summer.

The severity of the disease depends on the number of leafhoppers on the plant. When maize is not available, they breed and multiply on various grasses.

Importance

May be serious in late planted crops in coastal areas.

Control

1. Cultivars differ in their tolerance to the disease. Do not plant highly susceptible cultivars in coastal districts during summer.
2. Spraying with a recommended insecticide to reduce high leafhopper populations is beneficial, particularly in young crops.

Sweet potatoes

FIELD DISEASES

Bacteria and mycoplasmas

Little leaf

Mycoplasma-like organism

Symptoms

Affected plants are stunted, often with many small thin shoots. Leaves are small and yellow, particularly around the margin. Yields are reduced considerably when infection occurs early in the life of the plant.

Source of infection and spread

The organism causing big bud occurs in a number of crop plants and weeds and is spread by a small brown leafhopper. Because symptoms develop slowly over a period of four to eight weeks after infection, infected planting material may not show symptoms of the disease.

Importance

Periodic epidemics.

Control

Do not take cuttings from plants showing big bud symptoms.

Fungi

Scurf

Monilochaetes inuscanis

Symptoms

A grey to black surface discolouration of roots. No internal breakdown occurs and the appearance only is affected.

Source of infection and spread

The fungus survives on infested sweet potato residues in the soil. However, if affected roots are used for producing planting material, the fungus may grow on the base of the shoots and be carried into the field. It is then washed down onto developing roots. Cuttings can also transmit the disease. The disease is most serious in wet areas of the field.

Importance

Common.

Control

1. Use only disease-free roots for production of planting material.
2. Rotate sweet potatoes with other crops.
3. Dip planting material in recommended fungicide.

Fungicide treatment (for control of soft rot [*Rhizopus* sp.] and scurf in planting material).

Tubers. Dip in dicloran (750 g/kg) at 130 g/100 L (or 20 g/15 L). Wash tubers free of soil before dipping. Keep dip agitated. Discard dip each day or sooner if heavily contaminated with soil or vegetable matter.

Rooted cuttings. Dip in dicloran (750 g/kg) at 100 g/100 L (or 17 g/15 L). Keep dip agitated and discard each day or sooner if heavily contaminated.

Stem and foliage scab

Sphaceloma batatas

Symptoms

Stems and leaf veins are covered with small sunken scabby brown lesions, which cause distortion of the foliage. Severely affected terminals are brittle and the growing points may be killed. Infected patches are visible from a distance due to the erect growth habit of infected terminals. Severe disease outbreaks reduce the vigour of the crop, and if infection develops early in the season yields are severely reduced.

Source of infection and spread

The fungus survives in the regrowth and trash from infected crops. Planting material collected from infected regrowth introduces the disease into new crops. The disease is favoured by mild humid conditions and spread is rapid during drizzly weather.

Importance

The disease has only been recorded in north Queensland and is severe where growers have used the regrowth of previous crops for planting material.

Control

1. Destroy regrowth of infected crops.
2. Use healthy planting material produced in a nursery established from healthy tubers.
3. The cultivars Centennial Gold and Beerwah Gold are resistant.

Nematodes

Root-knot nematodes

Meloidogyne spp.

Symptoms

Galls or swellings form on the small roots while on the fleshy roots swollen areas, scab-like abrasions or cracks appear. Small brown spots are visible in the underlying tissues.

General

Root-knot nematodes are common even in virgin soil. The disease is most severe in crops on lighter soils and in late summer when nematode activity is high.

Importance

Occasionally serious.

Control

1. Fumigate the soil before planting.
2. Do not grow cowpeas or other very susceptible cover crops before sweet potatoes.

Preplant fumigation (for control of nematodes when planting infested areas). Apply one of the treatments listed below.

Treat the soil with EDB at recommended label rates to achieve 110 kg of EDB/ha. Inject the liquid in rows 300 mm apart. Seal the surface after injection by light rolling or a light spray irrigation. Leave the soil undisturbed for 7 to 14 days then cultivate to aerate the soil. For best results, soil should be warm and moist and free from undecomposed organic matter. If the soil is too wet, the fumigant does not diffuse properly and if too dry, diffusion from the soil is too rapid.

Treat the soil one to seven days before planting with fenamiphos (400 g/L) applied at the rate of 24 L/150 to 300 L of water/ha. Use a boom spray at 150 to 200 kPa as an overall treatment. Incorporate to a depth of 100 mm with rotary hoe or discs as soon as possible after application. Apply while the soil is moist after rain or irrigation.

Fenamiphos is extremely dangerous. Follow safety directions on label.

Viruses

Potyvirus

Symptoms

Infected plants do not always develop symptoms. Development of symptoms is influenced by the rate of growth, plant age and weather conditions. Symptoms include a mild mottle on young leaves.

Yellow (chlorotic) spotting may also develop while purple ringspots occur on some cultivars.

Source of infection and spread

The virus can be spread by aphids or through the use of infected planting material.

Importance

Widespread but minor if virus-free cuttings are planted.

Control

Use only good quality planting material. Discard any with probable symptoms of virus disease.

POST-HARVEST

Fungi

Storage rot

Rhizopus stolonifer

Symptoms

A soft watery rot of fleshy roots becoming covered with a mass of greyish white fungal growth in which large numbers of small black stalked fruiting bodies appear.

Source of infection and spread

The fungus is common and enters through wounds. It is mainly a post-harvest problem but can invade roots and cuttings used for planting. The fungus may spread from root to root by contact.

Importance

May be serious.

Control

1. Handle roots carefully to avoid damaging them.
2. Dip planting material in recommended fungicide.

Fungicides

Refer to the scurf control entry (see p. 63).

Tomatoes

FIELD DISEASES

Bacteria and mycoplasmas

Bacterial canker

Corynebacterium michiganense pv. *michiganense*

Symptoms

Leaves: a wilting of leaflets on one side of the leaf. These yellow and die, giving the leaf a one-sided appearance. One or both sides of the plant may be affected.

Stem: light brown cankers develop. When a diseased stem is cut, a brown discolouration of the water-conducting tissues is seen. This may extend into the leaf stalks. With time, the tissues in the centre of the stem turn brown, appear mealy and cavities develop.

Fruit: circular spots, up to 3 mm wide, with a raised brown central area surrounded by a pronounced white halo. As the spots age, the central area cracks giving a ragged appearance.

Source of infection and spread

The disease is commonly introduced in seed. Once established in a plant, the bacterium is then spread to healthy plants in sap, the extent of spread depending on how much the plants are handled at transplanting and during trellising and pruning.

The bacterium may survive on alternative weed hosts and undecomposed tomato residues in the soil.

Importance

Major if seed is not appropriately treated.

Control

1. Use disease-free seed. If none is available, treat in acid or hot water.
2. Rotate seedbeds frequently.
3. Avoid planting areas containing undecomposed tomato residues.
4. Check for affected plants during trellising and pruning. Carefully remove the young affected plants if numbers are small. Losses from the disease are minor if infection occurs after the first hand has set.

Treatment of old trellis wires and posts before re-use

Where the disease is a serious problem, dip in a 2% formalin solution.

Seed treatment

Seed which has been acid extracted is free from tobacco mosaic virus and surface-borne bacterial canker, bacterial spot, bacterial speck and target spot. For control of internal seed infections, treat seed in hot water at 55°C for 25 minutes. If seed has not been acid extracted, also soak in a 10% trisodium

phosphate solution for one hour after the seed has cooled from the hot water treatment. Make sure the seed is well wetted. After soaking, wash thoroughly for several hours in running water. Sow into a fumigated seedbed (see p. 67) or a sterilised potting mixture or jiffy pots as hot water treated seed is more prone to pre-emergence rotting. Do not use thiram seed dressings because of phytotoxicity. Remember to site seedbeds well away from other tomato or potato crops and preferably on soil that has not recently grown these crops.

Bacterial speck

Pseudomonas syringae pv. *tomato*

Symptoms

Leaves and stem: small black greasy spots similar to, but generally smaller than, those caused by bacterial spot. When spotting is severe, the entire leaf yellows. On the stem, spots are more elongated.

Fruit: raised black specks rarely more than 1 mm wide. These may coalesce to form large spots similar to those of bacterial spot.

Source of infection and spread

The bacterium is commonly introduced in seed. Once established on a plant, it is spread during wet windy weather and by overhead irrigation water. Warm humid weather favours the disease.

The bacterium may survive on undecomposed tomato residues in the soil.

Importance

Serious and difficult to control in wet weather.

Control

1. Spray with recommended fungicides.
2. Use the recommended seed treatment.
3. Destroy old crops promptly.

Fungicides

Seedbed (for control of target spot, bacterial spot, bacterial speck). Refer to target spot control (see p. 71).

Field.

Chemicals: copper oxychloride, copper hydroxide.

Add copper oxychloride or copper hydroxide to either mancozeb, propineb or chlorothalonil when required. Essential during prolonged wet weather.

Seed treatment

Refer to bacterial canker (see left).

Bacterial spot

Xanthomonas campestris pv. *vesicatoria*

Symptoms

Leaves and stem: small greasy spots becoming dark tan to black. Leaves turn yellow and fall.

Fruit: small raised circular black spots with a distinct water-soaked margin. As the fruit enlarges, spots increase in size up to 8 mm wide and become slightly sunken with a central scab. Only the outer skin is affected. Mature fruit are resistant to infection.

Source of infection and spread

The bacterium is commonly introduced in seed. Once established in a plant, it is then spread during wet windy weather and by overhead irrigation water. Warm humid weather favours the disease.

The bacterium survives on undecomposed tomato residues in the soil and on a number of common weeds.

Importance

Serious and difficult to control in wet weather.

Control

1. Spray with recommended fungicides.
2. Use the recommended seed treatment.
3. Destroy old crops promptly.

Fungicides

As for bacterial speck (see p. 65).

Seed treatment

Refer to bacterial canker (see p. 65).

Bacterial wilt

Pseudomonas solanacearum

Symptoms

A rapid wilting of foliage particularly noticeable during the warmest part of the day. Stunting frequently precedes the wilting, and leaflets and leaf stalks may curl downwards. Where the disease has developed slowly, large numbers of adventitious roots are produced along the stem above ground level.

If the stem is cut across at ground level, a brown discolouration of the water-conducting tissues just beneath the bark will be seen. A milky exudate is also apparent if the end of the cut stem is placed in a glass of water.

Source of infection and spread

The bacterium is a soil inhabitant particularly active in hot wet weather. It survives from season to season on undecomposed tomato residues and by invading a number of common weeds. Once established, the organism spreads rapidly through the crop by irrigation and rain water, particularly down slopes. Plant-to-plant spread may also occur by root contact.

Importance

Moderate. Causes high losses on individual farms.

Control

1. Avoid planting into known infested areas in summer.
2. Use disease-free soil for seedbeds and do not apply animal manure or excessive amounts of nitrogenous fertilisers.
3. Resistant cultivars (Scorpio, Redlands Summertaste and Redlander) are available. Resistance may breakdown during periods of high soil temperature.

Big bud

Mycoplasma-like organisms

Symptoms

A reduction in growth of the stem followed by yellowing and purpling of the growing tip and a pointing upwards of the flower hands. Flowers and flower stalks are enlarged with green petals. Multiple shoots may form in the leaf axils producing a rosette appearance.

Source of infection and spread

Many cultivated plants and weeds are susceptible. The organism is spread by a leafhopper. The disease is generally most severe when dry weather causes the vegetation around a crop to dry off and leafhoppers move into the crop. Subsequent spread within the crop is generally very limited.

Importance

Minor. Occasional serious epidemics occur.

Control

Not generally warranted.

Fungi

Anthracnose

Colletotrichum atramentarium

Symptoms

On ripe fruit, small circular slightly sunken water-soaked spots, enlarging up to about 10 mm wide and becoming pink then dark in the centre because of the formation of spores and small black fruiting bodies of the fungus.

Source of infection and spread

The fungus survives on crop residues. Spores produced are spread to fruit during wet windy weather. Susceptibility to infection increases as the fruit ripen. Symptoms are evident only on ripe and near-ripe fruit.

Importance

Minor.

Control

Spray with the recommended fungicides, mancozeb, propineb or chlorothalonil. Refer to target spot control section (see p. 71).

Buckeye rot

Phytophthora nicotianae var. *parasitica*

Symptoms

On fruit, a greyish-green to chocolate-brown firm rot with an indefinite, water-soaked margin and often with broad zonate markings. The surface of the rot is generally smooth and the skin is intact. Although the rot progresses well into the flesh, affected fruit remain firm.

Source of infection and spread

The fungus is a soil-inhabiting water mould and requires water for spore production and fruit infection. The disease is generally confined to fruit on or near the ground and consequently the disease is mainly a problem in ground crops. The spores of the fungus are splashed up from the soil during rain or irrigation. Warm wet weather favours infection and disease development. The disease is worst in low-lying or poorly drained areas of the field. Fruit showing small spots are often overlooked in packing and develop extensive decay in transit and storage.

Importance

Minor. More serious in ground crops in wet weather.

Control

Avoid planting tomatoes in infested areas.

Damping-off

Rhizoctonia solani

Symptoms

A collapse of seedlings with their stems shrivelled and water-soaked at soil level. Seed may also rot before emergence.

General

The fungus is a widely distributed soil inhabitant. Damping-off is generally not a problem in well-prepared fumigated seedbeds or in soil-less potting mixes.

Importance

Common problem in poorly prepared seedbeds.

Control

1. Raise seedlings in fumigated seedbeds.
2. Thin seedlings to permit good air circulation.
3. Avoid excessive watering.

Preplant soil treatment

Chemical: methyl bromide.

Apply at a rate of 1 kg/10 m² of seedbed. A 680 g can is sufficient to treat 6.8 m² of seedbed.

Chemical: dazomet (980 g/L) granules.

1. Soil must be moist before application for fumigation to be effective.
2. Using rubber gloves, sprinkle granules evenly over the surface of the seedbed at the rate of 50 g/m².
3. Dig into the soil to a depth of 200 mm.
4. After incorporation, cover with a plastic sheet.
5. Remove the plastic cover and loosen the soil five to seven days later. Soil should be ready for planting 10 days later. However, as a safeguard, always conduct a germination test. To do this, obtain two small glass jars with airtight screw-top lids, placing soil from the treated area in one and soil from the untreated area in the other. Put lettuce seeds on moist cotton pads and place inside both jars. Check germination after three days at room temperature. If the seeds in the jar containing treated soil have germinated normally, the soil is ready for planting. If not, cultivate again to allow more aeration and recheck.
6. Remember to avoid recontaminating sterilised soil.

Fusarium wilt

Fusarium oxysporum f. sp. *lycopersici*

Symptoms

A yellowing of leaves near the base of the plant followed by wilting which is particularly noticeable in warm weather. Sometimes only one branch of the plant shows definite symptoms. Diseased leaves readily break away from the stem and, if the bark is stripped off the plant just above ground level, a reddish-brown discolouration of the water-conducting tissues will be seen.

Source of infection and spread

The fungus is a soil inhabitant penetrating the roots and growing up through the water-conducting tissues of the stem and leaves. Occasionally, it also grows into the fruit, infecting the seed. The fungus survives from season to season in the soil and may be spread on contaminated implements and in soil washing down slopes. It requires warm temperatures (25° to 32°C) to develop, affecting plants only during the spring and summer.

Importance

The fungus occurs as three races. Race 1 is common to all districts of Queensland. Race 2 has been recorded only from the Bowen district while race 3 is widely distributed in the Bowen district and has also been found near Childers. Cultivars with resistance to all races are now available.

Control

1. Use the recommended resistant cultivars.

Cultivars

Resistant to race 1 only - Indian River, Scorpio, Floradel, Strobelee, Tropic.

Resistant to races 1 and 2 - Duke, Walter, Floradade, Redlands Summertaste, Redlander, Delta Contender, Red Chief, Pirate, Sunny.

Resistant to races 1, 2 and 3 - Selection 2-3.

Note: When selecting cultivars, factors besides disease reaction need to be considered. Always consult your local extension officer for further information.

Grey mould/ghost spot

Botrytis cinerea

Symptoms

Infections usually occur at a point of damage or where old blossoms fall onto the leaves, stem or fruit. A water-soaked greyish area develops which is soon covered by a grey brown furry mould. Stems or branches may be girdled causing wilting of the foliage. Flowers are often blighted. Two types of fruit symptoms occur. One consists of pale ring-like spots known as ghost spots on otherwise healthy fruit. The other is a soft rot with growth of the grey brown furry mould on affected surfaces. Hard black sclerotes often develop at the stem end of the fruit in the later stages.

Source of infection and spread

The furry mould contains large numbers of spores which are readily carried by wind. Cool wet weather favours infection.

The fungus has a wide host range and survives either as sclerotes or on undecomposed crop residues.

Importance

Common and often severe.

Control

1. Minimise damage to the crop during cultural operations especially trellising.
2. Do not slash the tops of plants during periods when cool moist conditions can be expected to occur.
3. Avoid having sequential plantings close together.
4. Spray with the recommended fungicides.

Fungicides

Chemicals: Chlorothalonil and iprodione.

The fungus will develop resistance to iprodione if it is used continuously. To prevent resistance chlorothalonil should be used until flowering or in situations of low disease severity. As disease pressure increases, use chlorothalonil and iprodione alternately. Under high disease pressure use a combination spray of chlorothalonil and iprodione.

Apply fungicides at approximately weekly intervals. Use at recommended label rates for the crop.

Grey leaf spot

Stemphylium solani

Symptoms

Leaves: small (1 to 3 mm wide) irregular dark brown or grey spots becoming lighter in the centre with age with a narrow pale yellow halo. Severely affected leaves yellow.

Source of infection and spread

The fungus is spread by wind-borne spores. Disease development is favoured by warm humid weather.

Importance

Minor due to use of resistant cultivars.

Control

Spray with the recommended fungicides mancozeb, propineb or chlorothalonil. Refer to target spot control section (see p. 71).

Irish blight

Phytophthora infestans

Symptoms

Leaves and stems: large dark brown to black areas. In moist weather, affected leaves rot and show a white downy growth on the underside. With a return to fine conditions, affected areas become dry and papery.

Fruit: decay generally begins at the stem scar as small greenish-brown spots which rapidly develop to produce large mottled brown areas with an indefinite margin. The rot is generally firm but the surface often becomes rough as the decay advances. If affected fruit are stored under humid conditions, a white downy growth may develop on affected areas particularly over the stem scar.

Source of infection and spread

The white downy growth produced on affected areas in moist weather contains large numbers of spores which are spread by wind. Cool wet weather is essential for infection and disease development. As winters in Queensland are relatively dry, serious outbreaks are rare.

Fruit showing no noticeable symptoms of the disease at harvest may develop extensive breakdown in transit and storage.

Importance

Minor.

Control

Spray with the recommended fungicides mancozeb, propineb or chlorothalonil. Refer to target spot control section (see p. 71).

Leaf mould

Fulvia fulva

Symptoms

Indefinite yellow spots on the top surface of leaves with a dark velvety growth of the fungus on the underside of each spot. Older leaves die prematurely, leaving the plant with a ragged appearance.

Source of infection and spread

The velvety mould produced on the underside of affected leaves contains large numbers of spores which are spread by wind. Warm wet weather favours infection.

Importance

Serious in north Queensland during wet periods and occasionally serious in south Queensland.

Control

Spray with the recommended fungicides mancozeb, propineb or chlorothalonil. Refer to target spot control section (see p. 71). Alternatively, spray with benomyl (500 g/kg) at 50 g/100 L when the disease is first seen and repeat at 14-day intervals. Where the disease has been a serious problem previously, commence spraying at flowering.

Phoma rot

Phoma destructiva

Symptoms

Fruit: dark sunken spots on cracks and other damaged areas. Close examination of the spots reveals a pimpled appearance in the centre. The diseased tissue remains quite firm unless invaded by secondary organisms.

Source of infection and spread

The fungus enters the fruit through wounds. It is generally seen only in seasons of high rainfall. Development occurs more rapidly on ripe fruit.

Importance

Rare.

Control

The spray programme recommended for control of target spot will control this disease (see p. 71). Fruit should be handled carefully during harvesting and packing to avoid injury.

Powdery mildew

Leveillula taurica

Symptoms

Spots appear mainly on the lower leaves of the plants. At first the spots are yellow and later develop into light brown slightly zonate areas. Sporulation of the fungus on the underside of the leaves is seen with

difficulty. Otherwise the symptoms resemble those of leaf mould. Defoliation may follow severe outbreaks.

Source of infection and spread

The fungus is spread by air-borne spores. Warm dry weather favours disease development.

Importance

Occasionally severe, particularly at Bowen.

Control

Spray with the fungicide benomyl (500 g/kg) at 50 g/100 L when the disease is first observed and at intervals of 7 to 14 days.

Rhizoctonia rot

Rhizoctonia solani

Symptoms

On green fruit, small circular brown spots with definite concentric ring markings. As the fruit ripen and the affected areas enlarge, these markings may disappear with the spots becoming dark brown and the centre breaking open. A brownish mould often develops on the surface of the spots.

Source of infection and spread

The fungus is a common soil inhabitant attacking a wide range of plants. It affects only fruit on or close to the soil. Warm wet weather favours infection and disease development. If affected fruit are packed, extensive breakdown may occur during transit and storage, particularly if fruit are not cool-stored.

Importance

Can be serious in ground crops, otherwise minor.

Control

1. Do not pack fruit showing signs of infection.
2. Cool fruit promptly after harvest.

Root and foot rot

Fusarium solani

Symptoms

Affected plants show yellowing and death of leaves, become stunted and eventually wilt. A dry brown rot of the crown and roots is evident. Damping-off of seedlings also occurs.

Source of infection and spread

The fungus is soil-borne.

Importance

Restricted to the Bowen district where it may be serious.

Control

Crop rotation. Soybeans or lablab are commonly used.

Sclerotinia rot*Sclerotinia sclerotiorum***Symptoms**

A light coloured rot of the stem and a wilting of the tips of affected branches. In moist weather, white fungal growth may appear on the affected areas. Large hard black irregular resting bodies (sclerotia) form inside affected tissues. Eventually, the whole plant wilts and dies.

Source of infection and spread

The sclerotia of the fungus can survive in the soil for many years. In cool moist conditions, those near the surface germinate to produce at the soil surface small cream, 'mushroom-like' bodies (apothecia). These contain large numbers of ascospores which are forcibly discharged and spread by wind. Infection occurs at points of injury or where dead flowers and leaves remain in contact with healthy tissues.

In dry seasons when the soil surface dries out rapidly after irrigation, conditions are unsuitable for the development of apothecia. Under these conditions of alternate drying and rewetting of the soil, the sclerotia may germinate directly and infect the base of the plant.

Sclerotinia rot is favoured by cool wet weather but fogs, mists dews and irrigation provide enough moisture for infection.

Many cultivated plants and weeds are susceptible to this disease.

Importance

May be serious in cool weather but can be controlled by fungicides.

Control

1. Spray with recommended fungicides.
2. Avoid planting heavily-infested areas in the cooler months.

Fungicides

Chemicals: benomyl (500 g/kg) at 100 g/100 L, iprodione (500 g/kg) at 100 g/100 L, procymidone (275 g/L) at 150-200 ml/100 L.

Commence when the disease is first seen and repeat at intervals of 14 days. Where the disease has been a serious problem previously, commence at flowering.

Sclerotium base rot*Sclerotium rolfsii***Symptoms**

At first a purple to dark brown discolouration of the base of the stem from soil level to a depth of 100 mm. The stem then becomes girdled, and the plant wilts and dies. On the surface of the affected area, a white cottony growth of the fungus develops in the midst of which small white spherical resting bodies (sclerotia), about 1 mm in diameter, form. These soon become brown and resemble cabbage seed.

Fruit which contact the soil may become infected. As they rot, large numbers of the sclerotia are produced.

Source of infection and spread

The fungus is a common soil inhabitant and attacks a wide range of plants. It is favoured by warm temperatures and moist soils, and is often severe in plants grown in poorly prepared land containing undecomposed plant residues.

Importance

Common, occasionally serious.

Control

If the disease was serious in past seasons, ensure that all plant residues are completely decomposed before planting. Drench transplants with the recommended fungicide.

Fungicide drench of transplants (where Sclerotium base rot has been a serious problem).

Drench the base of each transplant with 250 mL of a suspension of quintozone (750 g/kg) at 5 g/L.

Septoria spot*Septoria lycopersici***Symptoms**

Leaves: small spots, 3 to 4 mm wide, with brown margins and a light grey centre studded with small black fruiting bodies of the fungus. Severely affected leaves may yellow.

Source of infection and spread

The small black fruiting bodies contain large numbers of spores which are spread by wind and water. Warm weather favours infection and disease development. The fungus survives on undecomposed tomato residues in the soil.

Importance

Rare.

Control

Spray with the recommended fungicides mancozeb, propineb or chlorothalonil. Refer to target spot control section (see p. 71).

Target spot*Alternaria solani***Symptoms**

Leaves: dark brown zonate spots with definite margins and yellow edges, commonly up to 6 mm wide but as large as 12 mm when weather conditions are particularly favourable.

Stem: spots resemble those on leaves but tend to be more elongated and the 'target' appearance is more pronounced. An affected seedling shows a large dark, dry, sunken area on the stem near the ground level. The plant is stunted and may break at this point.

Fruit: black or dark brown, oval to round spots commonly on the edge of the stem scar or around growth cracks. Spots develop rapidly as the fruit ripens.

Source of infection and spread

Large numbers of spores produced on leaf and stem spots are spread from plant to plant by wind, rain and irrigation. Warm weather favours the disease but it is still present to some extent throughout the year and may spread even in relatively dry weather. It develops more rapidly when plants are under stress.

Importance

Serious disease problem requiring regular spraying.

Control

1. Use disease-free seed.
2. Plant into well-prepared seedbeds.
3. Spray with the recommended fungicides in both the seedbed and the field.
4. Rotate crops so that tomatoes do not follow either tomatoes or potatoes. Potatoes also harbour the disease.
5. Destroy old crops immediately after harvesting.

Fungicides

Seedbed (for control of target spot, bacterial spot, bacterial speck).

Use a mixture of mancozeb (800 g/kg) 2 g/L combined with either copper oxychloride 4 g/L or copper hydroxide 2 g/L. Mancozeb alone is not recommended in seedbeds because of phytotoxicity.

Field.

Chemicals: mancozeb, propineb, chlorothalonil.

1. Begin seven days after transplanting and repeat at 7 to 14-day intervals. Use the shorter interval if prolonged wet weather occurs.
2. If bacterial diseases are a problem, use a mixture of mancozeb (800 g/kg) at 150 to 200 g/100 L combined with either copper hydroxide (540 g/kg) at 200 g/100 L or copper oxychloride (500 g/kg) at 400 g/100 L. These rates are for high volume application (1000 L/ha on a mature crop). If lower spray volumes are used the spray concentration should be increased so that an equivalent quantity of fungicide is applied per hectare.

Seed treatment

Refer to bacterial canker (see p. 65).

Verticillium wilt

Verticillium dahliae

Symptoms

The lower leaves turn pale and lose lustre. Leaf margins are often dead. During the heat of the day, wilting occurs. Disease progression is gradual. Plants do not die immediately but are stunted and unthrifty. The leaf canopy is more open than in healthy plants. If the back is removed from the stem near ground

level a pale brown discolouration of the water-conducting tissues will be seen.

Source of infection and spread

The fungus is a common soil inhabitant penetrating the roots and growing up through the water-conducting tissues of the stem. It is spread on contaminated implements and by soil washing down slopes.

The fungus attacks a number of other crop plants including potatoes and a prior potato crop often increases the severity of the disease in tomatoes. Some weeds, for example Noogoora burr (*Xanthium pungens*), are also susceptible and movement of this weed in floods may be responsible for introducing the fungus into previously clean areas.

Cool temperatures favour disease development.

Importance

Most recently released cultivars are resistant to race 1. Race 2 is common and often severe in southern Queensland. The disease is rarely serious in northern areas.

Control

1. Avoid following potatoes with tomatoes.
2. Treat the seedbed and field with recommended fumigants.
3. Keep crop areas free from Noogoora burr and other susceptible weeds.

Preplant soil treatment

Chemical: dazomet (980 g/L) granules.

1. Soil must be moist before application for fumigation to be effective.
2. Use rubber gloves, sprinkle granules evenly over the surface of the seedbed at the rate of 50 g/m².
3. Dig into the soil to a depth of 200 mm.
4. After incorporation, cover with a plastic sheet.
5. Remove the plastic cover and loosen the soil five to seven days later. Soil should be ready for planting 10 days later. However, as a safeguard, always conduct a germination test as indicated in the damping-off (*Rhizoctonia*) control section (see p. 67).
6. Avoid recontaminating sterilised soil.

Cultivars

Cultivars resistant to race 1 are Duke, Floradade, Tropic, Redlands Summertaste, Redlander, Delta Contender, Red Chief, Sunny and Pirate. There are no race 2 resistant cultivars available.

Note: When selecting cultivars, factors besides disease reaction need to be considered. Always consult your local extension officer for further information.

Yeasty rot

Geotrichum candidum

Symptoms

Fruit: water-soaked to bleached areas often beginning at cracks or injuries to the skin or at the stem scar. In green fruit, affected areas generally remain quite firm until the decay is well advanced. In ripening fruit, the decay progresses rapidly, eventually causing complete collapse. Cracks in the skin over affected areas are generally filled with a whitish scum-like mass of fungus.

Source of infection and spread

The fungus is common on decaying plant matter in the soil. It is spread to fruit by wind and water, infection occurring only through the stem scar or injuries to the skin. Hot wet weather favours infection and disease development. Although most infection originates in the field, extensive spread may occur during harvesting and packing, particularly if heavy rains have fallen before and during harvesting thereby increasing fruit cracking and skin injuries from adhering soil. High storage temperatures favour rapid development of the rot.

Importance

Common during hot, humid weather.

Control

As for Rhizopus soft rot (see p. 75).

Fungicides

As for Rhizopus soft rot (see p. 75).

Zonate leaf spot

Gloeocercospora sorghi

Symptoms

Affects leaves, stems and blossoms. The symptoms are similar to those of target spot except that the lesions on the leaves are larger and more obviously zonate.

Importance

Occasionally severe, particularly at Bowen.

Control

Not warranted.

Nematodes

Root-knot nematodes

Meloidogyne spp.

Symptoms

Galls or swellings on the roots. Affected plants are stunted and yellow and wilt readily on hot days. Plants may die prematurely.

Source of infection and spread

Root-knot nematodes are common, even in virgin land, and affect a wide range of crops. Worm-like larvae about 0.5 mm long enter roots causing the formation of galls.

Nematodes may be spread by transplanting infested seedlings, and in soil washed down slopes or adhering to farm machinery and workers. The disease is most serious on light sandy soils during the warmer months.

Importance

Only a problem where infested soils are not treated with a pre-plant nematicide.

Control

1. Immediately after the final harvest plough-out affected crops to expose the roots to the wind and sun.
2. Plant the area with a recommended cover crop. Do not use cowpea, mung bean or velvet bean.
3. Fumigate the seedbed.
4. Treat affected areas with the recommended nematicide before planting.

Preplant soil treatment

Seedbed.

Chemical: methyl bromide.

Apply at a rate of 1 kg/10 m² of seedbed. A 680 g can is sufficient to treat 6.8 m² of seedbed.

Chemical: dazomet (980 g/L) granules.

1. Soil must be moist before application for fumigation to be effective.
2. Using rubber gloves, sprinkle granules evenly over the surface of the seedbed at the rate of 50 g/m².
3. Dig into the soil to a depth of 200 mm.
4. After incorporation, cover with a plastic sheet.
5. Remove the plastic cover and loosen the soil five to seven days later. Soil should be ready for planting 10 days later. However, as a safeguard, always conduct a germination test as indicated in the damping-off (Rhizoctonia) control section (see p. 67).
6. Avoid recontaminating sterilised soil.

Field.

Chemical: EDB193.

1. Treat soil at least two weeks before planting.
2. Use two drills 300 mm apart and 200 mm deep applied to the intended plant row and roll after treatment.
3. Use at a rate of 37 L/ha (that is, 72 kg EDB/ha). To obtain this rate, dilute one part of EDB193 with five parts water and apply 66 mL of the diluted product/10 m of each drill.
4. Use other formulations of EDB at recommended label rates.

Chemical: fenamiphos spray.

Apply one to seven days before planting using a boom spray at 150 to 200 kPa. Apply in a 600 mm band to the intended plant row at the rate of 160 mL/1.4 to 2.8 L of water/100 m of row onto moist soil. Incorporate as close to spray as possible with hoe or discs to 100 mm. Overall treatment requires

24 L/150 to 300 L of water/ha. This nematicide is extremely dangerous. Follow directions on label.

Viruses

Fern leaf

Cucumber mosaic virus

Symptoms

The first symptom is a thickening and rolling of the leaf edges. Later, the terminal shoots become a mass of very narrow distorted leaflets all with thickened and curled edges. Fruit on affected plants may be malformed.

Source of infection and spread

The virus has a wide range of hosts among crop and weed species. It is spread from plant to plant by aphids.

Importance

Minor, but regularly occurs in some districts.

Control

Not warranted.

Mosaic

Tomato mosaic virus

Symptoms

Affected plants are generally lighter in colour than healthy plants. Individual leaves are slightly crinkled and show a distinct light and dark green mosaic, particularly at low temperatures. The virus also causes a pale blotching and internal browning of the fruit.

Source of infection and spread

The main sources of infection are contaminated seed, other affected tomato crops, undecomposed tomato residues in the soil, old trellis material and contaminated hands and clothing of workers. Crops and weeds related to tomatoes such as tobacco, cape gooseberries and blackberry nightshade may be sources of infection.

The virus is highly infectious and is readily spread on hands, implements, and pruning knives and by direct contact between plants.

Importance

Can be serious but can be well controlled if all precautions are followed.

Control

1. Destroy old crops of tomatoes and related species in the vicinity.
2. Use commercially treated seed or treat seed with trisodium phosphate (TSP).
3. Avoid handling seedlings after working in an older crop or, if this is not practicable, wash hands thoroughly and dip in TSP.

4. Treat pruning knives and implements with TSP after working in a diseased crop. Wires and posts should also be treated before reuse.

Treatment of old trellis wires and posts before re-use

Spray with a 10% trisodium phosphate solution. Planting boxes should also be sprayed before transplanting and workers should wash their hands in the solution before handling young seedlings, particularly where they have previously been working in an older crop of tomatoes.

Seed treatment

Refer to bacterial canker (see p. 65).

Leaf shrivel

Potato virus Y

Symptoms

Down-curling of leaflets and petioles which gives the leaf a 'clawed' appearance. Leaves may also be mottled and leaf area of the plant reduced. Older leaves may show a dark grey to brown spotting on the underside, and eventually shrivel and die. Fruit show no symptoms though total yield is reduced.

Source of infection and spread

The virus is transmitted by several species of aphid. The main sources of infection are old infected tomato, capsicum and tobacco crops, and weeds such as gooseberries (*Physalis* spp.), nightshades (*Solanum* spp.) and apple-of-Peru (*Nicandra physalodes*).

Importance

Widespread and often severe, especially late in the season.

Control

1. Destroy old tomato crops and related species.
2. If capsicums are being grown concurrently, use a capsicum cultivar resistant to the virus.
3. Site seedbeds well away from older tomato crops.
4. Control aphids with recommended insecticides.

Spotted wilt

Tomato spotted wilt virus

Symptoms

Leaves: a cessation of growth followed by a temporary bending downwards of the leaf stalk. Purplish-brown spots then appear on young leaves, often giving them a reddish-brown or bronze colour. The spots are often crescent-shaped and up to 3 mm long. Affected leaves may wither and die.

Stems: dark streaks may appear near the growing point when the disease is severe.

Fruit: pale ringspot areas sometimes with browning on ripening fruit.

Source of infection and spread

A large number of weeds and ornamental plants are susceptible to this virus. It is spread by thrips and is most common in spring when thrip populations increase rapidly.

Importance

Minor but serious losses may occur in spring in some districts.

Control

Control weeds around the crop.

Tomato yellow top

Tomato yellow top virus

Symptoms

Infected plants are stunted, assume a stiff upright appearance and from a distance are markedly chlorotic. Symptoms include reduced leaf size, rounding and marginal chlorosis of leaflets and downcurling of leaflet margins. Flowers often fail to set fruit and flower buds can be killed following infection. Yield can be drastically reduced if plants are infected at an early stage, but infection later has progressively less effect. No symptoms are produced in the fruit.

Source of infection and spread

The virus is spread by the potato aphid (*Macrosiphum euphorbiae*) and more importantly by the green peach aphid (*Myzus persicae*). Several other species of plants are also susceptible to the virus, including potato and the weeds thornapple (*Datura* spp.), apple-of-Peru (*Nicandra physalodes*), nightshades (*Solanum* spp.) and shepherd's purse (*Capsella bursa-pastoris*).

Importance

Common, especially during autumn in coastal areas.

Control

Of limited value. Control the aphid vectors and susceptible weed species. Isolate new crops from older infected crops.

POST-HARVEST

Bacteria and mycoplasmas

Soft rot

Erwinia carotovora pv. *carotovora*

Symptoms

On fruit, slightly depressed water-soaked spots, enlarging rapidly to affect most of the fruit which becomes soft and watery and easily breaks open. Affected fruit have an offensive smell.

Source of infection and spread

The bacterium is common in soil and decaying vegetable matter and enters the fruit through wounds. The disease is mainly a post-harvest problem and the bacterium may become established in and around the packing shed. Rains before and during harvesting favour the rot because of an increase in fruit cracking and mechanical damage from soil adhering to the fruit. High storage temperatures favour disease development.

Importance

Generally minor.

Control

1. Handle fruit carefully to avoid damaging the skin.
2. Keep the packing shed free from rotting fruit.
3. Avoid harvesting in wet weather.
4. Dip fruit in the recommended bactericide.

Post-harvest treatment

Chemical: sodium hypochlorite 50 ppm available chlorine required: for example, 160 mL of commercial bleach containing 3.5% sodium hypochlorite/100 L. Add a wetting agent.

Completely submerge or thoroughly shower fruit with the solution then pass over grader and elevator as soon as possible to remove excess solution. Allow to dry before packing. Check the concentration regularly with a swimming pool test kit and maintain at the recommended level. Replace dip entirely when it becomes contaminated with dirt and trash. Cool-store fruit where possible.

Fungi

Alternaria rot

Alternaria alternata

Symptoms

Fruit: dark brown to mouldy black sunken spots which enlarge as the fruit mature. Spots generally appear on the shoulders of the fruit around the edges of the stem scar and around growth cracks or other small injuries to the skin.

Leaves: the fungus has been recovered only from dead tissues around powdery mildew spots. A closely

related fungus has been found associated with a large zonate leaf spot.

General

The disease is generally serious following rain in cultivars having fruit prone to growth cracks.

Importance

A post-harvest disease occasionally serious in fruit from the Bowen district.

Control

Fungicides suitable for post-harvest dipping are not currently registered.

Rhizopus soft rot

Rhizopus stolonifer

Symptoms

Fruit: soft, slightly water-soaked spots with little discolouration, developing rapidly to affect the entire fruit. The skin may remain intact with little sign of external mould but affected fruit frequently split and collapse into a soft mass that is quickly overrun by the fungus. Black stalked fruiting bodies develop in this growth.

Source of infection and spread

The fungi are common on decaying plant matter and spores are spread by wind. Infection generally occurs

through wounds, but in storage may spread from fruit to fruit by contact. The disease is mainly a post-harvest problem, and the fungus may become established in and around the packing shed. Heavy rains just before and during harvesting favour development of the rot because of an increase in fruit cracking and mechanical damage from soil adhering to the fruit. High storage temperatures also favour disease development.

Importance

Occasionally serious in market consignments.

Control

1. Handle fruit carefully to avoid skin damage.
2. Discard fruit with serious growth cracks and other injuries.
3. Remove reject fruit from the vicinity of the packing shed.
4. Treat fruit with the recommended post-harvest fungicide.

Post-harvest treatment

Chemical: dicloran (500 g/kg) at 120 g/100 L plus wetting agent.

Completely submerge or thoroughly shower fruit with the solution then pass over grader and elevator as soon as possible to remove excess solution. Allow to dry before packing.

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